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A THEORY-BASED METHODOLOGY FOR ANALYZING DOMAIN SUITABILITY FOR EXPERT SYSTEMS TECHNOLOGY APPLICATIONS

JAY ASHLEY HORN, CAPTAIN, USAF

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A THEORY-BASED METHODOLOGY FOR ANALYZING DOMAIN SUITABILITY FOR EXPERT SYSTEMS TECHNOLOGY APPLICATIONS

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

By

JAY ASHLEY HORN
B.S., United States Air Force Academy, 1984

1989
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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Jay A. Horn ENTITLED A Theory-Based Methodology for Analyzing Domain Suitability for Expert Systems Technology Applications BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science.

Thesis Director

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ABSTRACT

Horn, Jay Ashley. M.S., Department of Biomedical and Human Factors Engineering, Wright State University, 1989. A Theory-Based Methodology for Analyzing Domain Suitability for Expert Systems Technology Applications.

This thesis chronicles the development of a theory-based methodology for analyzing candidate application domains for expert systems technology solution. There is clearly a need for a methodology of selecting expert systems application domains that has firm theoretical underpinnings. To support that goal, four theories of human cognition are evaluated. Gestalt theory, stimulus-response theory, information processing theory, and the Structure of Intellect theory (SOI) are assessed against the criteria of construct validity, reliability, and operational utility.

The SOI theory is selected as the framework for identifying the kinds of information and mental processes (the information elements) essential to satisfactory performance in a given domain. The SOI theory forms the basis of the Domain Suitability Analysis Tool (DSAT). By using an established theory of human cognition, the methodology enjoys a high level of construct validity for describing the knowledge components of a domain.

The DSAT is hypothesized to specify the information requirements of a domain, present the data in an easily interpreted format, and possess both reliability and validity. The DSAT outputs can then be used to assess the degree of supportability for the domain requirements based upon the current level of expert systems technology. This allows the decision-maker to assess the degree of suitability of this domain for an expert systems technology solution.

The DSAT's operational utility and reliability are investigated in two separate studies. Results of the studies indicated a significant degree of operational utility and reliability among domain experts. Additionally, findings of the reliability study

offered some degree concurrent validity with research being conducted in the field of cognitive science.

A discussion of the potential contribution of the DSAT methodology in such areas as knowledge acquisition, cognitive engineering, and functional allocation of tasks between man and machine is presented. Future research issues, such as refinement and automation of the tool, additional validation, and empirical development of the Domain Suitability Index factor weights is also discussed.

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1.0 INTRODUCTION

The science of artificial intelligence and its related subfields of expert systems, robotics and machine vision, and natural language processing have recently exploded into the forefront of scientific and engineering research and applications. Expert systems, defined as knowledge-based systems that emulate expert performance to solve significant problems in a particular domain of expertise (Sell, 1986), are currently receiving the a great deal of attention. Since many excellent treatments exploring the characteristics of expert systems have been written (Waterman, 1986 and Sell, 1986) no formal examination of expert systems will be offered. However, the basic process of designing expert systems will be examined, together with the implications of that design process relative to selection of application domains suited to expert system techniques.

In the pages that follow, competing theories of human cognition will be evaluated against the criteria of validity, reliability, and operational utility to select a theory capable of defining the information requirements of specific domains. After specifying a taxonomy of the domain information elements that directly contribute to domain performance, a methodology for comparing the degree of support offered by expert systems technology will be developed.

The procedures necessary to perform an accurate evaluation of potential application domains for expert systems technology using the theory-based model have been integrated to create the Domain Suitability Analysis Tool (DSAT). The DSAT has been designed to be both theoretically valid and operationally efficient. Validation of the DSAT is achieved by examining several diverse application domains (to which expert systems suitability had previously been established) and comparing the recommendations of DSAT against the existing knowledge of the domain's suitability.

Additional benefits of the DSAT process are discussed, as well as areas for additional improvement. With an overview of the DSAT development in mind, it is appropriate to formally define the problem investigated in this research effort.

1.1 **PROBLEM STATEMENT.** There are no theoretically based, empirically established methods for determining domain suitability for applying rule-based expert systems technology. While several ad hoc guidelines have been proposed, at best, they provide only general guidelines for determining if a domain can benefit from rule-based implementations of expert systems technology. Hadzikadic, Yun, and Ho (1987) succinctly state the problem:

> As expert systems technology becomes increasingly popular for (yet) untested applications, a serious gap in knowledge has become increasingly prominent - the appropriateness of the match between a prospective application domain and the tools of ES (expert systems) (p. 64).

A methodology which allows the knowledge engineer (or program manager) to accurately determine the degree of success achievable by pursuing an expert systems technology solution in a particular problem domain is the goal of this research.

Attaining the above goal can facilitate the application of scarce resources to areas where the greatest utility would be derived. The tool can act as a funnel to allow program managers to direct time, capital, and personnel into domains suited to artificial intelligence techniques. Similarly, it can assist decision-makers in determining the level-of-effort for domains showing possible success, while also identifying areas of higher risk.

Another potential outcome of this research is an increased understanding of the importance of the user's unique information requirements to perform the task and their impact on the design of rule-based expert systems. Addis (1985) has indicated that a more complete understanding (rooted in theory and establishment of in-depth techniques) of the human factor in the process of expert system design is required if the science is to move forward.

Kidd and Sharpe (1988) are also concerned with the lack of theoretically based research which accounts for human expertise in artificial intelligence. They regard the current generation of expert systems as experiments, which have focused impressive amounts of computational power on specific problems in highly isolated domains, but have yet to achieve sufficient basis in theory to allow growth into diverging domains. They write:

> Success of the system is directly determined by the appropriate representation and application of specific knowledge from that domain to solve an isolated problem. Despite the vast amount of data now available as a result of these experiments, we are still unable to explain the "why" or "how" of successful systems or to predict for which other domains and tasks the current techniques will work. This is because no theory of tasks or domains currently exists (p. 147).

The taxonomy of the domain information structure that is specified by this research can be useful in identifying critical areas of the domain deserving additional attention during the expert systems design process. The taxonomy can also be used to estimate the allocation of functions between the operator and the machine, based upon the structure and processing required of specified information elements.

The proposed theory-based methodology discussed in this thesis is designed to aid decision-makers in determining which application domains hold the greatest promise of solution by rule-based expert system techniques. Additional benefits of this research include focused attention on the human element of the expert system design process, use of theory to advance artificial intelligence and expert systems science, assistance in identifying man-machine allocation issues (functional allocation of resources), and identification of deficient areas of expert systems technology requiring additional research.

1.2 TYPICAL DEVELOPMENT OF AN EXPERT SYSTEM. In order to better understand the potential contribution of this research, it is important to first discuss how expert systems are developed and the intended impact the proposed tool will have on the process. The development of an expert system typically follows a logical progression from problem identification to system release. Allen (1987) has reviewed the development process as described by five expert systems researchers. The five methodologies are presented in Table 1.

While using different terminology, each of the authors agree some type of problem identification is required in the initial step. The focus of the activities performed in this first step one is not identical between authors, however. Polit (1985) emphasizes the "problem recognition" step which examines both potential problem domains and the appropriateness of expert systems technology as a problem solution. Waterman (1986) also suggests the appropriateness of the problem domain relative to expert systems techniques is critical in the system development process. The Systems Manufacturing Technology Group recognizes expert systems are not applicable to all disciplines and only applicable domains should be pursued (Allen, 1987).

Hayes-Roth, Waterman, and Lenat (1983) stress the identification step as central to the entire expert system development project. Here, knowledge engineers evaluate the structure of the problem's tasks and strategies in terms of compatibility with the proposed expert system's capabilities. Frieling, Alexander, Messick, Rehfuss, and Schulman (1985), do not specifically address domain evaluation relative to expert systems as an important facet in the development process.

1.3 CURRENTLY USED CRITERIA FOR DOMAIN SELECTION. With the understanding that domain analysis is appropriate and necessary to the development of an expert system, it is useful to examine the methods currently used in domain analysis. The criteria now in use derive from early theoretic models and guidelines.

1.3.1 EARLY THEORETIC APPROACHES OF DOMAIN SELECTION. The early theoretic approaches lay the ground work of the present research. For example, the Additive Rating Model Methodology (ARMM) of Bringelson, Deer, McCray, Thompson, and Salvendy (1987) attempted to define a method of specifying job tasks and skills in terms of expert systems capabilities (much in the manner of a job

TABLE 1

Summary of the Steps in the Development of an Expert System

Polit (1985)	Hayes-Roth, et al. (1983) and Waterman (1986)
Step 1: Problem Recognition	Identification
Step 2: Task Definition	Conceptualization
Step 3: Initial Design	Formalization
Step 4: Knowledge Acquisition	Implementation
Step 5: Knowledge Maintenance	Testing

Freiling, et al. (1985)	Systems Manufacturing Technology Group (1982)
Phase 1: Knowledge Definition	Phase 1: System Design
Step 1: Familiarization	Phase 2: Prototype Development
Step 2: Knowledge Organization	Phase 3: Making the Expert
Step 3: Knowledge Representation	Phase 4: Evaluation and Acceptance
Phase 2: Prototype Implementation	Phase 5: Use in Prototype Environment
Step 4: Knowledge Acquisition	Phase 6: Development of Maintenance Plans
Step 5: Strategic Decision	Phase 7: System Release
Step 6: Interface Design	

(Source: Allen (1986), p. 50.)

analysis). After a job expert selects the relevant task (or tasks) of the job in question from the task list, the task/skill matrix is used to evaluate the likelihood of success using an expert system approach.

The task list (from Waterman, 1986) defines 11 tasks "involved in knowledge-based systems." The 24 skills involved in those tasks are specified from the work of Lenorovitz, Phillips, Ardrey, and Kloster (1984) that examined skills used in human-computer interactions. Table 2 illustrates this matrix. The model does not address the types of information used in task completion and is a serious limitation.

There are several areas that raise some concerns of the validity of this matrix. First, neither the task nor skill lists possess a firm theoretical basis. While using the concept and basic emphasis of job theory, both lists rely primarily on observations of the researchers and may not capture the fundamental elements of the job. Second, given the lists measure the necessary job elements, the skills represented are about 1984, and not reflective of current expert systems capabilities. A more useful tool will possess flexibility to measure the domain against state-of-the-art expert systems capabilities.

The product of the matrix evaluation is a numerical rating of the skills encompassed in a task (see Table 2). The scores can range from 0 (no skills are replicable) to 24 (all skills are replicable). Higher scores imply more skills can be replicated by the computer better defining the task and resulting in better task performance. The scores for each task of a job are then summed and divided by the number of tasks to obtain a composite score. Bringelson, et al. (1987) define scores above 17 (one standard deviation above the mean task score of 11.73) as "good" (expert systems are applicable), scores 12 to 17 as "marginal" (expert systems may be applicable with support from other considerations, such as cost), and scores below 12 as "poor" (expert systems do not apply).

TABLE 2

Skills, Tasks, and Scores Used in the Additive Rating Model Methodology

Skills that can be emulated using current expert systems technology (Lenorovitz, Phillips, Ardrey, and Kloster, 1984.)

Detect	Search	Scan	Extract	Cross-Reference
Recognize	Categorize	Calculate	Itemize	Discriminate
Tabulate	Estimate	Translate	Compare	Interpolate
Formulate	Integrate	Evaluate	Select	Extrapolate
Acknowledge/ Respond		Direct/ Inform	Ungroup/ Segregate	Filter

Tasks performed in a job domain (Waterman, 1986), their associated scores of skill components, and qualitative suitability (with appropriate score range) for expert systems applications.

GOOD		MARGINAL		POOR	
(17.00 - 24.00)		(11.73 - 16.99)		(0.00 - 11.72)	
Diagnosis	- 23	Instruction	- 15	Design	- 11
Conflict resolution	- 23	Monitoring & gathering	- 11	Information	- 11
Prediction	- 21	Creating	- 8		
Planning	- 21				
Interpretation	- 20				
Delegation	- 19				

(Source: Bringelson, Deer, McCray, Thompson, and Salvendy, 1987.)

While the method makes a useful contribution in pursuit of a hierarchical structuring of tasks, there does appear to be some lack of sensitivity in the middle range of scores. For example, at most only 11 tasks are scored. Domains that encompass all of these tasks (or more) would all be rated at 11.73, the mean, suggesting expert systems technology would not be warranted. The researchers do suggest weighting coefficients could be determined for different job domains by the job expert, but again these weights would have to be empirically established and validated.

A possible low level of reliability of the tool is evidenced by the high variability of ratings of various job domains revealed during the validation of the ARMM. The validation of the tool involved correlation of responses of expert systems practitioners to applicability of expert systems technology to a list of 24 job domains. While the experts and ARMM agreed on the top three fields (medical diagnosis, computer system configuration, and equipment fault diagnosis) and bottom three (key punch operations, artistry, and music composition) for expert systems application, there was very little consensus in the middle range fields (examples are sports coaching strategies, fashion consulting, and telephone directory assistance).

In effect, the tool confirms much of what we already know (which is useful). Unfortunately, the ambiguous job domains are the most prevalent, and this is where the tool must be accurate. Since there is no expert consensus in any domain, we must have an objective framework, based in theory, to give a clear picture of the potential domain in light of the current technology.

While the overall concept of the Additive Rating Model Methodology (ARMM) is laudable, there are several problems that encourage additional research. The difficulties of achieving high levels of validity and reliability, identifying relevant information types and processes used in the job, and achieving sensitivity among complex domains all point toward the need for a theoretically-based approach that can ameliorate these deficiencies and provide useful direction for domain assessment.

TABLE 3

List of "Primitives" for Describing
Potential Application Domains

1. Recognize	7. Infer
2. Classify	8. Refine
3. Compare	9. Construct
4. Specify	10. Explain
5. Simulate	11. Execute
6. Analyze	12. Prescribe

(Source: Hadzikadic, Yun, and Ho, 1987.)

Some interesting work that falls into the early theoretic category has been done by Hadzikadic, Yun, and Ho (1987). They have developed 12 "primitives" to be used in characterizing the components of an application domain (see Table 3). The primitives combine to define higher level processes such as diagnosis and repair.

Based upon the notion that humans organize information into a mental-model and then modify the state of that mental-model by using operators, Hadzikadic, Yun, and Ho argue the operators used can define the problem-solving process used. Knowledge of these operators, or primitives, therefore characterizes the central aspects of a domain. These "building blocks" can be combined to represent any process particular to a domain.

While this approach has some merit, neither the notion of the mental-model" nor the primitives derived are based on any specified empirically derived theoretical constructs. The model examines the processing aspects of domains, but like the ARMM, encounters difficulties in describing the types of information required for satisfactory domain task performance. Also the level of sensitivity of the method for discriminating among complex domains does not appear to be high.

1.3.2 GUIDELINES FOR DOMAIN SELECTION. While each of the researchers cited by Allen (1987) identifies the selection of a suitable problem domain as an important (and often critical (Prerau, 1985)) step in the development process, none go farther than suggesting a few broad guidelines for making this selection. Several ad hoc guidelines for domain selection have been proposed. Table 4 lists several of the observations cited by Prerau (1985) and Dreyfus and Dreyfus (1986) as typical of these guidelines.

The major objection to these guidelines is they are based simply on ad hoc observations of past successful cases. Dreyfus (1979) quotes AI researcher Drew McDermott, "... AI (and expert systems) is a field starving for a few carefully documented failures" (p. 46). By only examining the "successes" of any endeavor,

TABLE 4

Guidelines for Selecting an Appropriate Expert Systems Application Domain

---

Dreyfus and Dreyfus (1986).

1. No algorithmic solution to the problem should exist.

2. The problem can be satisfactorily solved by human experts at such a high level that somewhat inferior performance is acceptable.

3. Non-experts have a high probability of making a poor decision.

4. Poor decisions have significant impacts.

5. The problem is stable during the time taken to make a decision.

6. The knowledge domain must be relatively static.

7. An expert must be available to provide the knowledge base.

Prerau (1985). (This list is a sample of his 52 guidelines.)

1. The domain is characterized by the use of expert knowledge.

2. Conventional programming approaches to the task are unsatisfactory.

3. There are recognized experts that solve the problem daily.

4. Experts are probably better than amateurs in performing the task.

5. There is a need to "capture" the expertise for the future.

6. The task is neither too easy nor too difficult for an expert.

7. Domain selected offers the greatest return for the projected risk.

8. The task primarily involves symbolic reasoning.

9. The task requires the use of heuristics and may require the consideration of many alternatives or decisions based on incomplete or uncertain information.

10. The task inputs and outputs are clearly defined at the outset.

(Source: By listed author.)

useful information and "lessons learned" are lost. The conclusions drawn from this kind of analysis are subject to error and tend to be incomplete.

A second problem with these guidelines is the lack of clear recommendations regarding the utility of expert systems technology for a specific problem. Use of general guidelines places the decision-maker in the position of making potentially cost-intensive decisions based on largely subjective estimates using incomplete criteria.

The current guidelines do not provide specific guidance regarding functional allocation of duties between the user and system. The theoretically-based methodology proposed here attempts to produce a model of domain and expert system attributes that can be used to examine the relative strengths and weaknesses of the man-machine dyad. This knowledge can be used in the manner of the Fitts' list (Meister, 1985) to better allocate duties between the human and machine on cognitively oriented topics.

1.4 THE NATURE OF THE PROBLEM. Some examples of traditional methodologies of building expert systems have been described. In the aggregate, each of the traditional methods require some effort in initially defining or identifying relevant aspects of the candidate domain. This supports the assumption that the information requirements of a domain are the most salient factors in attempting definition and understanding of the domain. In practice, however, the identification and structuring of the domain knowledge necessary for adequate performance is often gathered using painstaking and inefficient interviews, known as knowledge acquisition. Unfortunately, the entire success or failure of an expert system is usually determined in the knowledge acquisition phase. Any improvements of this step would make a significant improvement to the expert system development process.

1.4.1. EXPERT SYSTEMS KNOWLEDGE ACQUISITION. The knowledge acquisition process is typically performed by a knowledge engineer (or engineers) who interviews and questions the domain expert (or experts) using real and hypothetical examples of cases to determine the heuristics used by the experts. When these "rules of thumb" are stated in an "if-then" format, a rule-based model of domain expertise is created (Klahr and Waterman, 1986).

This set of rules forms the basis for the rule-based expert system. If this set of rules is incomplete or in error, the system will not perform at intended levels. Revision of the rule-set and additional expert interviews (sometimes several) are required to bring the system up to acceptable levels of performance.

The problem of a usually long and tedious cycle of interviews and rule-set revisions has been referred to as the "knowledge acquisition bottleneck" (Feigenbaum, 1977, p. 71). Waterman (1986) has observed the knowledge acquisition step can extend "... over a period of many months." New methods of knowledge acquisition that allow the expert to communicate directly with the machine to develop rule-sets have been developed to circumvent this problem (see Quinlan, 1987, for some examples). However, the need to refine and correct the knowledge initially gained is still evident in spite of these new methods (Klahr and Waterman, 1986).

Many reasons have been offered to account for the difficulties encountered in knowledge acquisition. For example, experts are believed to have difficulty articulating the deeper-level rules they use, experts may forget to include rules they take for granted (common sense), and/or experts may make incomplete or erroneous assumptions. Generally, the difficulties center around the problems inherent in the interview process and getting domain experts to translate largely intuitive processes into verbal representations.

1.4.2 THE ROOTS OF THE PROBLEM. Artificial intelligence and expert systems researchers have failed to notice the traditional approach used in building rule-based expert systems constrains the domain analysis to only those elements supported by the current level of technology. Herein lies the cause of the "bottleneck" problem. This bias towards the limitations of expert systems technology can prevent system designers from adequately understanding the domain and those information elements critical to successful performance in that domain. Figure 1 depicts the steps involved in the traditional approach.

In Step 1, the *Expert Systems Capabilities Space* is developed through experience by the knowledge engineer. As he performs the knowledge acquisition process in Step 2, a *Domain Information Requirements Space* is developed based on rules elicited from the *True Domain Information Requirements Space* via the domain expert. In Step 3, the *Expert Systems Capabilities* are mapped onto the *Elicited Domain Requirements Space*, apparently covering the entire domain. However, in Step 4, after actual use, system performance is often found to be less than expected. When the *Expert Systems Capabilities Space* is mapped onto the *True Domain Requirements Space*, a significant portion of the domain is often found to be unsupported, resulting in poor system performance.

An appropriate model of human cognitive task execution applied to the knowledge acquisition process would result in a more complete and valid representation of the domain. Figure 2 outlines the use of such a model in the development process. Steps 1 and 2 use theory to specify and define both the domain elements and capabilities of expert systems. In Step 3, mapping the two together results in a more accurate estimate of the degree of support (coverage) that can be expected by using a rule-based expert systems approach.

Development of theory through basic research, while critical to the evolution and establishment of a science, is resource-intensive and usually does not generate profits "in the current financial quarter." Therefore, vital basic research is either not performed or is left to academia. Hence, many areas that could benefit from theory through improved methods and products rely on empirical data, "rules of thumb," and just plain hard work and ingenuity on the part of dedicated systems designers to fill-in the theoretical gaps and advance the state-of-the art. Gaines and Shaw (1988) provide

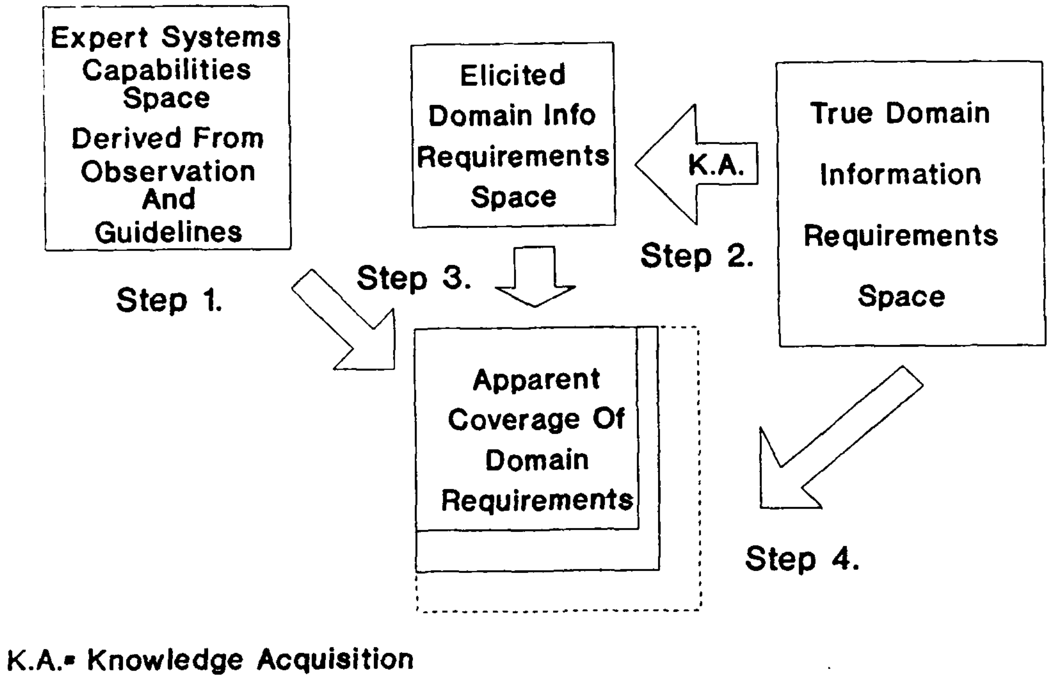

Figure 1. Traditional Approach to Building Expert Systems.

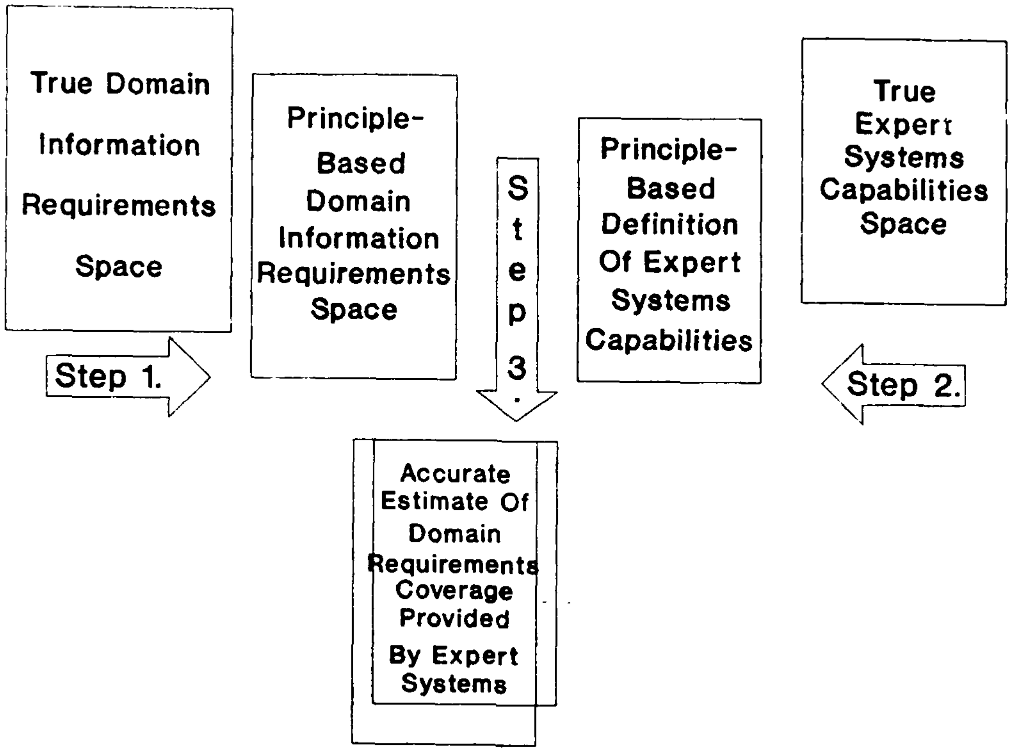

Figure 2. Principle-Based Approach to Building Expert Systems.

an enlightening examination of the field of human computer interaction (HCI) that proposes several eras of evolution for any scientific endeavor. It is interesting to note that they find HCI and related fields entering the "era of theoretical development," which supports the direction of this research.

1.4.3 SUMMARY OF THE PROBLEM. In the rule-based expert system development process, domains are typically evaluated using rule-based expert systems attributes as the standard of comparison and not theoretically derived models of human cognitive task performance. Due to this bias, no theory-based models have been suggested for use in examining domains for rule-based expert systems suitability. Ad hoc guidelines and some early theoretic methodologies have arisen to fill the void, but the difficulties of attaining construct validity, identifying task relevant information types and processes, and attaining sensitivity among complex domains indicate that a more acceptable solution must be found.

The next section explores alternative theories of human cognition to be considered in development of a domain suitability analysis tool (DSAT).

2.0 THEORETIC RATIONALE FOR DSAT

This chapter evaluates four of the leading theories of human cognition and intelligence against the criteria of validity, reliability, and operational utility to derive a theoretical basis for the development of a domain suitability analysis methodology.

The two objectives of AI research are developing models of human cognition and developing intelligent artifacts (Sell,1986). The current emphasis has certainly been on the latter objective, but not at the expense of the former. Dehn and Schank (1982) state "... AI is no longer concerned with computers at all (it is) therefore not about anything artificial but is simply about intelligence" (p. 357). Therefore, applying solid theories of human cognition should aid in the advancement of artificial intelligence science.

While no "unified" theories of cognition currently exist to solve all the problems of artificial intelligence researchers, significant research has been performed, resulting in at least four schools of thought (Sternberg and Detterman, 1986; Sternberg and Lasaga, 1981): psychometric, stimulus-response, Gestalt, and information-processing theories.

2.1 PSYCHOMETRIC THEORIES OF INTELLIGENCE. The psychometric theorists use individual differences data (refined through the use of factor analysis) to separate patterns of reasoning ability from other abilities and to examine the various reasoning skills exhibited. These various methods have relied on the individual-differences data for testing and formulating theories (Guilford and Hoepfner, 1971).

Spearman, who refined the factor analysis method, is regarded as one of the first psychometric theorists. He developed a two-factor theory of intelligence (specifically for intelligence testing) which proposed a single, central element of intelligence, *g*

(Spearman, 1904). The second factor was originally believed to be a factor of intelligence unique to that specific test, and would be undiscernable by any other test.

However, as results of factor analyses mounted, there appeared to be other related factors that intercorrelated more strongly than initially predicted by the theory. Spearman called variables common to a specific group of tests "group factors." He attempted to downplay the importance of these factors, emphasizing the importance of *g* instead (Guilford and Hoepfner, 1971).

Thurstone (1938), intrigued by the existence of group factors, used over 50 different intelligence tests to uncover a number of intellectual factors in a large group of college subjects. He proposed a theory of primary mental abilities (PMA) composed of seven factors. These were verbal comprehension, numerical facility, spatial ability, perceptual speed, rote memory, induction, and deduction.

The next step in the growth of psychometric theories of intelligence came during World War II. J.P. Guilford, as director of Psychology Research Unit #3 of the Aviation Psychology Research Program, was asked to determine selection criteria for aircrew personnel in the intellectual area. Examination of the reasons students washed-out of pilot training revealed eight general psychological constructs: judgement, foresight and planning, memory, comprehension, visualization of flight path, spatial orientation, reasoning, and coordination of information. Guilford and Lacey (1947) performed an in-depth factor analysis of these constructs, and demonstrated approximately 25 intellectual factors.

After World War II, Guilford continued investigation of these factors of intelligence under the aegis of the Aptitudes Research Project for the Office of Naval Research. The early years of the project demonstrated all of Thurstone's primary mental abilities, as well as finding two aspects of his spatial factor; arrangement of objects in space, and visualizing changes in objects (Guilford, 1985). This brought the list of abilities to near 40.

As the list of factors began to mount, several similarities and differences became apparent. Some factors could be grouped based on the mental processes involved, such as cognition, memory, and evaluation. Others could be segregated based on the information used; symbolic, semantic, or visual, for example. A third dimension involved the form of the information used; units, classes, or relations, for example.

The resulting cubic figure that encompasses these dimensions is the Structure-of-Intellect (SOI) model (Guilford, 1967, 1985). Figure 3 shows the SOI model with its three dimensions: operations, contents, and products. This model illustrates the focus of psychometric theories on cataloging and systematically identifying the components of intelligence and cognitive behavior.

2.2 STIMULUS-RESPONSE THEORIES OF INTELLIGENCE. Learning is the primary aspect of the stimulus-response (S-R) theories of intelligence. Sternberg and Lasaga (1981) identify five common themes of S-R theories (from White, 1970, pp 665-666):

> a) The environment may be unambiguously characterized in terms of stimuli.
> b) Behaviour may be unambiguously characterized in terms of responses.
> c) A class of stimuli exists which, applied contingently and immediately following a response, increases or decreases it in some measurable fashion; these stimuli may be treated as *reinforcers*.
> d) Learning may be completely characterized in terms of various possible couplings between *stimuli, responses, and reinforcers.*
> e) Unless there is direct evidence to the contrary, classes of behaviour may be assumed to be learned, manipulable by the environment, extinguishable, and trainable.

The primary focus is on the role of past learning in shaping current decision making. Also, Sternberg and Lasaga (1981) point out that the S-R theory of intelligence is not favored in the study of intelligence, and is difficult to apply to complex problems even if it were in vogue.

2.3 GESTALT THEORIES OF INTELLIGENCE. The dominant theme in Gestalt theories of intelligence is structure of perceptions. Koffka (1935), Katona (1940), and Kohler (1947) have been the shaping researchers in this field. Kohler hypothesized

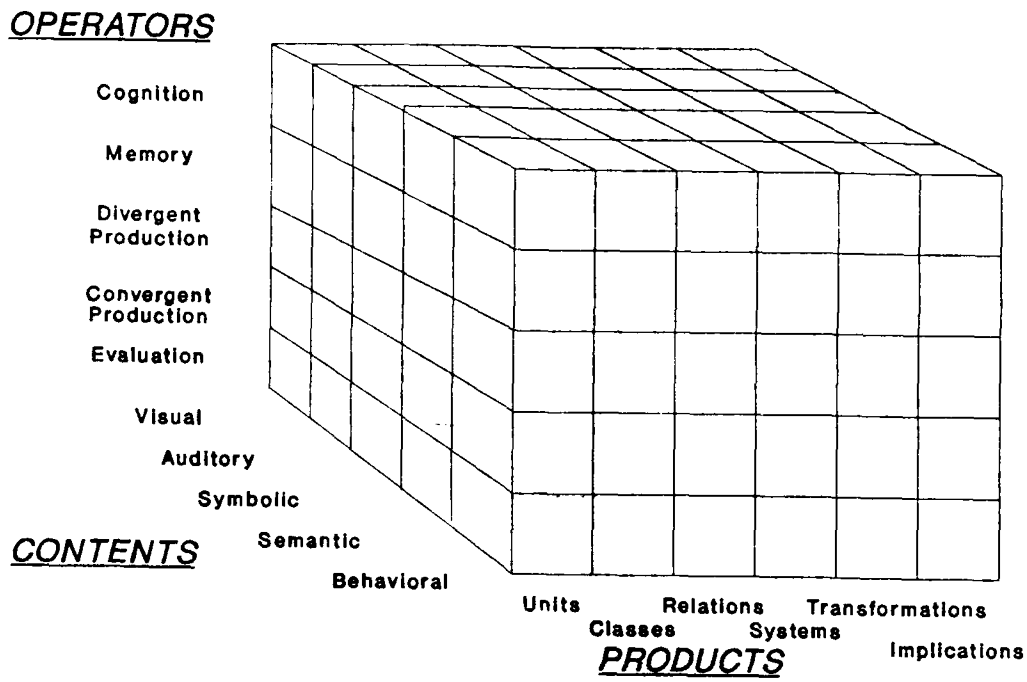

Figure 3. The Structure of Intellect Cube (Guilford, 1967; 1985).

learning occurs as elements are organized and structured in the mind ("restructuring of the perceptual field"). Also, he emphasized the role "insight" plays in problem solving. Koffka and Katona also stressed organization of information as the dominant feature of understanding.

For Gestaltists, the goal of understanding is achieved through purposeful restructuring of the problem space to achieve a meaningful whole. The solution to the problem is "discovered" when the missing "piece" of the puzzle is added to create a recognizable and intelligible representation of the problem.

2.4 INFORMATION PROCESSING THEORIES OF INTELLIGENCE. Sternberg and Lasaga (1981) identify information-processing theories as concerned with:

> ... the mental processes individuals use in reasoning, the strategies into which these processes combine, the representations upon which the processes and strategies act, and the knowledge base that is mentally represented.

The information-processing approach is currently the most favored approach for dealing with issues of intelligence (Sternberg and Salter 1982). After introduction almost three decades ago by Miller, Galanter, and Pribram (1960) and Newell, Shaw, and Simon (1960), it is still immensely popular, with the computer revolution a moving force behind this popularity. Sternberg's theory of information processing is probably the most dominant of the competing theories. (Sternberg and Lasaga, 1981, Wolman, 1985, and Sternberg and Detterman, 1986, all provide useful background into the other theories).

Sternberg (1985) postulates three aspects of information processing components, shown in Table 5. Metacomponents are the highest level functions of processing. Analogous to the executive control program, the ten metacomponents direct the selection of lower level performance processes and assess the effectiveness of those selections.

The lower level of information processing components are the performance components. These components execute the selected metacomponent strategies for a

TABLE 5

Sternberg's Theory of Information Processing

Three components of information processing:

I. The Metacomponents are higher-level, executive processes and consist of:

1. Identifying a problem exists.
2. Identifying the nature of the problem.
3. Selecting lower-order components to solve the problem.
4. Selection of a strategy of task completion using the lower components.
5. Selecting a mental representation of the information.
6. Decision of allocating attentional resources.
7. Monitoring current position in achieving the steps of problem solution determined in 4, above.
8. Understanding the quality of task performance through internal and external feedback.
9. Knowing how to act upon the feedback received.
10. Implementing the action based on the feedback results.

II. The Performance Components consist are lower-level processes used in the execution of task performance strategies and examples are:

1. Encoding the nature of a stimulus.
2. Inferring the relations between two stimuli.
3. Applying a previously inferred relation to a new situation.

III. The Knowledge-acquisition Components are processes used in learning information and storing it in memory and consists of:

1. Selective encoding, the selection of relevant information.
2. Selective combination, which involves organizing and combining the new information to maximize coherence and connectedness.
3. Selective comparison, the relation of new information to information already in memory.

(Source: Sternberg, 1985.)

given task. Examples include inferring relations between two events, or applying previously inferred relationships to new scenarios.

The knowledge-acquisition components are those mental processes used to store and learn new information. The three most important components of this aspect are selective encoding (sorting relevant from irrelevant information), selective combination (the combination of selectively encoded data to result in highly organized and coherent memory store) and selective comparison (selectively encoded and combined information is mapped to existing memory elements structure to facilitate recall and connectedness).

3.0 EVALUATION OF INTELLIGENCE THEORIES FOR DSAT

This section explores the criteria used in assessing the appropriateness of the four theories of human intelligence and cognition described in the previous chapter for use in identifying the types of information and processes of a domain.

3.1 CRITERIA FOR EVALUATION. The four approaches examined above have different strengths, weaknesses, and intuitive appeal. For use in DSAT, the theory selected must not only meet the traditional standards of validity and reliability, but also provide unambiguous definition of the principle aspects of the domain, be sensitive to differences in the domains, and lend itself to ease of application and development as a tool. Possessing validity and reliability makes the tool functionally sound. In addition, possessing the qualities of unambiguous definition, sensitivity, and ease of application makes the tool operationally practical and useful.

3.1.1 VALIDITY. The concept of validity attempts to define the degree an instrument or model measures what it is supposed to measure. Anastasi (1982) reports the three principal categories of this important measure as content, criterion-related, and construct validity. Anastasi continues that validity cannot be established for an instrument in a vacuum; validity must be established in light of a particular application. The relevance of each category with respect to the proposed tool is examined below.

3.1.1.1 CONTENT VALIDITY. Content validity seeks to establish the degree the instrument covers the behaviors evidenced in a particular domain. Instruments with high content validity encompass (measure) a large portion of the domain being examined. For example, a test to examine basic mathematics skills would have high content validity if it contained questions concerning addition, subtraction, multiplication, and division. Such a test would have low content validity, however, if it was to measure advanced calculus skills.

3.1.1.2 CRITERION-RELATED VALIDITY. Criterion-related validity involves an assessment of the ability of an instrument to predict outcomes in a specific situation. Concurrent and predictive validity are two aspects of interest of criterion-related validity.

Concurrent validity measures the agreement between the instrument's score or recommendation and other established indicators of the domain being examined. Using the above mathematics example, if a student who scored high on the test also had received high marks in mathematics courses, the test would possess concurrent validity. Anastasi (1982) points out that concurrent validity is relevant in diagnosis of existing status rather than prediction of future ability.

Concurrent validity is often used as an efficient alternative of assessing predictive validity. The time and cost required to properly assess predictive validity is often high (such as in a hazardous situation) making the use of concurrent validity strategies very attractive (Meister, 1985). By comparing the results of the test to existing indicators of performance, the degree of criterion-related validity is easily measured.

Predictive validity focuses on the prediction of future behavior based on the performance measured by the test instrument. Predictive validity is of interest in tests used for selection and classification of personnel. Screening applicants for pilot training, or identification of students likely to benefit from a specialized education program are two examples where predictive validity is relevant.

3.1.1.3 CONSTRUCT VALIDITY. Construct validity is probably the most difficult of the various validity concepts to adequately understand. Defined, construct validity is the extent to which an instrument measures a theoretical construct, or underlying trait. Sanders and McCormick (1987) consider construct validity to be assessed through "the accumulation of empirical evidence regarding the measurement in question" (p. 63).

3.1.1.4 RELEVANCE OF VALIDITY MEASURES. Content validity is an important measure in the evaluation of the alternative intelligence theories presented in this paper. The theory selected must cover a large portion of the intelligence aspects of the domain in question to allow proper assessment of the domain with respect to expert system technology capabilities.

Predictive validity is identified as being useful for screening future outcomes and concurrent validity useful for determining present status. The objective of the DSAT is to determine which problem domains can be successfully addressed using expert systems technology, therefore, concurrent validity is most relevant to the tool proposed in this study. The theory selected should possess concurrent validity when used in the proposed application.

Construct validity is the most "sought after" validity; a tool with construct validity will encompass the other aspects of content and criterion-related validity (Anastasi, 1982). The theory that is selected must have evidence of construct validity to insure the foundation of the DSAT is sound.

3.1.2 RELIABILITY. Reliability is the degree of stability or consistency of a measurement across representative samples or over time (Sanders and McCormick, 1987). This is a measure of the instrument's freedom from error; the extent to which differences in test scores are due to the "true" differences between the tested aspects of the subjects (Anastasi, 1982).

Reliability is often assessed by administering the test at one time, and then again at some future time. The correlation of the two scores is the reliability coefficient of the particular instrument. Sanders and McCormick (1987) report a reliability coefficient of 0.80 or better is considered satisfactory. The selected theory should be relatively free from random errors in application or evaluation to insure a highly reliable tool.

3.1.3 OPERATIONAL CONSIDERATIONS. There are other aspects of importance, besides the issues of validity and reliability, when designing a tool for practical use. For this application, unambiguous definition of the domain attributes, sensitivity to differences among similar domains, and ease of use are identified as relevant.

3.1.3.1 UMAMBIGUOUS DEFINITION OF DOMAIN ATTRIBUTES. Unambiguous definition of the domain attributes, while related to content validity, deserves special attention. As explained in the opening paragraphs of this paper, one goal of this research is to provide a tool that provides definitive recommendations to decision-makers regarding domain suitability. To provide this type of recommendation, the domain and expert system attributes must be specified and understood, with little room for alternative interpretations.

3.1.3.2 SENSITIVITY TO DOMAIN DIFFERENCES. Sensitivity to differences among domains also supports the goal described above. Since decision-makers will often be considering several (possibly related) domains for a particular expert system, the ability to differentiate among them is critical to providing useful recommendations of domain suitability. The selected theory of intelligence should provide a means of demonstrating domain differences.

3.1.3.3 EASE-OF-USE. Ease-of-use a critical aspect to the ultimate acceptance of any measurement tool. Practitioners of knowledge engineering often work under tight budget and time constraints. The tool that is easily administered, scored, and interpreted is the tool that is implemented. Tools with high face validity (the degree a tool appears to measure what is supposed to measure) are generally more accepted by users than those lacking face validity. Also, compact (parsimonious) tools are highly valued. Therefore, the theory of human cognitive task execution that is selected should address these ease-of-use criteria.

3.2 APPLICATION OF CRITERIA TO INTELLIGENCE THEORIES. Using the criteria listed above, the S-R and Gestalt theories are immediately discarded. Disregarding the issues of validity and reliability, their lack of structure, inability to discriminate between potential domains, and difficulty of application to complex problem domains makes them inappropriate for the envisioned tool. This leaves the psychometric (Guilford's SOI model) theory and the information-processing (Sternberg's components of intelligence) theory.

It is critical to remember the intended use of the theory selected. The goal of the present research is not understanding human intellectual functioning per se, but specifying the attributes of the information and processes of intelligence used in a particular problem domain. This catalog of attributes can then be compared to the catalog of attributes for a particular expert system (or general capabilities of expert systems technology) to assess the degree of compatibility between the two.

While the information processing approach is strongly indicated as relevant to understanding human cognition (particularly in terms of construct validity), it fails in several areas as a candidate for the domain analysis tool. Sternberg (1977), points out the information processing theories suffer from lack of parsimony. This is due to lengthy statements of processes, that interact with other processes. This leads to difficulty in assessing the contribution individual processes make. This translates into lack of sufficient sensitivity to discriminate between domains.

The reliability of the information processing approach is suspect for this application. The large number of processes required in defining domain intelligence can lead to omissions of important processes (or process relationships) that may result in failure to adequately capture the critical aspects of the domain. The random error that could be introduced is unacceptable for this application.

Next, only processes are accounted for; information types (the kinds of information used by the human to make domain specific decisions about task execution) are not addressed. This violates the criteria of sufficient content validity and sensitivity. The type of information is an important factor in expert systems applications. For example, auditory inputs such as engine noises (pings, chugs, etc.) are not directly usable by a computer. An automotive repair expert system would fail in situations where auditory evaluation is the primary diagnostic input. A useful domain analysis tool must make distinctions of information type.

The nature of the theory is troublesome for this application as well. The typical analog of the information processing theory is the digital computer. Since the goal of this research is the direct comparison of domain attributes to expert system technology attributes, the existing close relation of the information processing theory to expert system functioning may result in a "conflict of interest." Information processing theory will necessarily cast the domain of interest in its own image; defining the domain in terms that may not be appropriate to the domain, while implying more similarity between a domain and expert systems than may exist.

Several researchers believe that information processing theory is not the definitive theory of human intelligence and problem solving. Guilford (1985) points out that there is

> ... danger of trying to picture human information processing too much in the image of computer performance. The fact that the computer and the brain achieve similar results is not proof that they do so in the same manner (p. 238).

Dreyfus and Dreyfus (1986), citing the inability of artificial intelligence researchers to produce humanlike understanding using rules based on the mind's processes, argue "... the traditional view (information processing theory) of mind has shown itself to be inadequate." Sternberg (1977) writes that information processing theory examines the components of intelligence in depth, but at the expense of other possibly useful aspects. He and Lasaga (1981) build on that thought, suggesting a broad, integrated approach encompassing the most relevant aspects of both current and yet-to-be specified theories as the best hope for defining intelligence. Therefore, information processing theory is not indicated as applicable for the present application.

4.0 STRUCTURE OF INTELLECT MODEL

This section examines Guilford's Structure of Intellect model in terms of the selection criteria established in the previous chapter and specifies the rationale for selecting it over the competing theories of human intelligence.

Guilford's SOI model is the most logical choice as a theoretical basis for examining domain suitability with respect to rule-based expert systems technology. To summarize, reasons for selecting this model over the others are: sensitivity to many aspects of a domain and unambiguous representation of those aspects (over 150 attributes can be specified); the specificity of the SOI model will enhance the reliability of the tool; the SOI model is easy to understand (practitioners can intuitively grasp its focus); the SOI model has high content validity; and the SOI model has been developed over the past 40 years, resulting in several refinements and an "accumulation of empirical evidence" suggesting its construct validity for this approach.

4.1 CONTENT VALIDITY. The SOI model meets this criterion since the model examines over 150 facets of a domain. Specification of a particular operator, content, and product specifies the type of process, the type of information used, and the type of information produced during the activity. This model allows sufficient domain coverage to establish a high degree of satisfactory content validity.

4.2 CRITERION-RELATED VALIDITY. Both predictive and concurrent validities have been established for the SOI model in many different intelligence- and cognition-related applications such as intelligence testing, creativity measurement, and job selection (Guilford, 1985; Guilford and Hoepfner, 1971; Meeker, 1969). While the theory does possess satisfactory levels of criterion-related validity, the specific criterion-related validity for this application must be established.

4.3 CONSTRUCT VALIDITY. While the theory has existed for over three decades, it remains a viable tool for understanding the various aspects of human intelligence. Kolodner (1984) posits the structure of the information used in human intellectual problem solving is different in experts than in novices, based on her research. The importance of information structure cited by Kolodner in the mind of the problem solver suggests that a structural approach, like the SOI model, is useful in describing application domains. This lends some support to the existence of construct validity in this theory.

The SOI model has been used as a job analysis tool, which is similar to the envisioned DSAT. As cited above, Bringelson, et al., (1987) suggested using elements of job analysis in the evaluation of candidate domains. This observed correlation with other types of tests is also supportive of construct validity (Anastasi, 1982).

4.4 RELIABILITY. The layout of the SOI model and the terms used lend themselves to a reliable method of describing application domains and expert systems technology attributes. The development of logical and specific administration procedures will further insure the reliability of the instrument. Section 7.3 examines the results of a study conducted to assess the reliability of the developed tool.

4.5 OPERATIONAL CONSIDERATIONS. The nature of the SOI model lends itself to unambiguous definition of the various attributes under consideration in a domain. The vast majority of all attributes composing the SOI model have been operationally defined, significantly reducing the possibility of mis-identifying an attribute (Guilford, 1985). This characteristic is also useful in establishing the sensitivity of the theory. The significant number of attributes contributes to the ability to specify differences between domains.

This theory also appears to lend itself towards ease of use. The three dimensional layout of the model appears to be well suited for the desired tool, both in terms of administration and evaluation. The high face validity of the SOI model, which will be evident to practitioners, is another positive aspect that meets the ease-of-use criteria.

5.0 STATEMENT OF OBJECTIVES

Having selected a suitable theory of human cognition the objectives of this research can now be stated: The primary objective is to apply theory to achieve a tool capable of adequately describing the information requirements of a domain to allow the comparison of the domain information requirements with the capabilities of expert systems technology. Concurrent with this objective is presentation of the collected data in a manner which effectively conveys the significant information elements of the domain.

A secondary objective is the development of a preliminary means of combining the elicited domain information with the capabilities of expert systems technology to produce a recommendation of domain suitability. Also, an assessment of the reliability of the tool for analyzing domains will be undertaken. Finally, areas of future work for addressing the above goals will be discussed.

6.0 DEVELOPMENT OF THE DOMAIN SUITABILITY ANALYSIS TOOL

This section presents the rationale and development of procedures used to apply Guilford's SOI model to the task of defining a domain with reference to expert systems technology capabilities.

The SOI model offers a particularly useful means for quickly and efficiently examining a domain. This aspect is called the "psychoepistemology" by Guilford (1967). Thirty categories, termed content-product features are identified in the SOI model of fundamental characteristics of information, by examining a domain using this psychoepistemology, the basic information requirements of the domain can be captured.

Once the basic information elements of the domain have been described, the operations performed upon those elements can be identified. Guilford has selected five mental operations as relevant. These five elements compose the operator dimension of the model. Once the operators relevant to the domain in question are specified, the domain is defined in a manner suitable for comparison with the capabilities and limitations of expert systems technology.

A similar approach can be taken to specify the capabilities of expert systems technology. Using the SOI model, the range of information inputs and outputs supported by expert systems technology can be identified. The operations performed by the expert system can also be identified. The domain and the current state of expert systems technology can now be described in terms of a common denominator, the SOI model, facilitating their comparison.

By examining the degree of fit between critical areas of the domain and the same areas supported by the expert systems technology, it is possible to make inferences regarding the degree of domain suitability for an expert systems solution. Also, consideration of the frequency of occurrence of both information elements and required operators allow examination of the impact of a specific item on the overall suitability of the domain. For example, if a domain occasionally required processing of visual information and expert systems technology could only perform visual processing in a limited manner, but otherwise met the all of the domain's requirements, the decision-makers could then consider other alternatives, such as allocating visual processing to a human operator.

By providing decision-makers with relevant information about the degree and nature of the domain/expert systems compatibility, allocation issues between man and machine can be addressed and the development of partial solutions utilizing an expert systems approach can still be pursued. This information will prove extremely valuable since it will permit the decision-makers to see the effect of implementing alternative solutions in terms of the information requirements of the domain.

6.1 WORKING HYPOTHESES FOR DEVELOPING THE DSAT. In developing these procedures for evaluating domain suitability for expert systems technology, the primary assumption is the information requirements (that is, the kinds of information used to make task execution decisions and the processes used in making those decisions) of the domain dictate its suitability for expert systems solution. Human beings, who act in domains, function successfully in those domains using information organized as knowledge. The underlying organization (structure) of that information can be discovered by specifying the relevant information elements of the domain. Unfortunately, no universal taxonomies of domain information requirements exist for any problem domain. We therefore must query the domain expert in an attempt to understand the domain's requirements.

The DSAT is designed to describe the domain information elements (based on the SOI model) as revealed by the domain expert and then produce a recommendation based on the degree of support provided by expert systems technology for those information elements. While some researchers have attempted (with little success) to map domains in terms of expert systems capabilities, we define expert systems suitability in terms of the domain's information requirements.

Therefore, Hypothesis 1 states:

The DSAT will provide a description of the information types and processes used for performance of domain tasks by the human expert.

Another assumption regarding tool's development (as described earlier in Section 3.0) is that for the DSAT to be useful, it must be incorporate both the functional aspects of validity and reliability, and be easily implemented and interpreted. Practitioners will not use a tool that is cumbersome and difficult to understand, no matter how valid and reliable its developers claim it to be.

Since the SOI model includes 150 different components (and Guilford hypothesizes even more), domain evaluation requiring a question for each component could prove tedious for all but the most highly motivated people. Therefore, pursuing a method of "pruning the tree of possibilities" to reduce the analysis to a manageable size, but still retaining the power of the SOI approach, is of high priority. Hypothesis 2, then, states:

The DSAT will be easily administered, analyzed, and interpreted.

Hypothesis 3 states:

The DSAT will possess a high degree of reliability for describing domain information requirements.

Hypothesis 4 states:

The DSAT will possess a high degree of validity for describing domain information requirements.

6.2 ORGANIZATION OF THE DSAT. The basic procedure involves a series of questions about the domain of interest regarding the various dimensions of the SOI model. The DSAT has three sections: Part I examines the structural components based on the content-product aspects of the domain; Part II exaines the operational components, which incorporates the domain operators with element frequency, criticality and difficulty; and Part III, which presents the domain attributes in four levels of abstraction, leading to the domain suitability index which describes the overall domain suitability for an expert systems technology solution.

6.2.1 ASSESSING THE STRUCTURAL COMPONENTS OF THE DOMAIN. This is the first step in the DSAT process. By using the content-product dimensions of the SOI, a 30 element psychoepistemology is described which provides a means for determining the basic information elements evident in the domain. By having the domain expert indicate the presence or absence of each component, the structural information requirements for the domain are established.

This simple yes/no procedure reduces the sample space of possible SOI components by five with each "no" answer. For example, with 150 possible components (5 contents x 6 products x 5 operators), any content-product element not in the domain, eliminates five possible operators that could have acted upon it (see Figure 3). Also, we defer decisions regarding component frequency, criticality, and difficulty until the second step of the procedure, reducing the number of components (and time required for the interview) to be considered by the domain expert.

6.2.2 ASSESSING THE OPERATIONAL COMPONENTS OF THE DOMAIN. The second phase of the DSAT administration involves determining the relevant operators (mental functions) required to act on the information elements defined in the previous step, and to establish the criticality, frequency and difficulty of the various components to allow comparison with expert systems technology attributes. As an example, assume 10 of the 30 content-product elements are identified as domain-relevant in Part I. In Part II, the domain expert identifies which operators are relevant for each of the 10 elements and the degree of frequency, criticality, and difficulty associated with each.

The selection of the operator associated with the component is essential, since the operators (representative of mental activities) are generally the weakest links in expert system implementations, and the most significant contributions of the human to goal achievement. Their implementation is "weak" in the sense that researchers are not yet able to simulate the robust and flexible nature of most mental processes. Understanding the recurrence, importance, and level of context complexity of a particular operator within a domain becomes the foundation for decisions regarding supportability of successful performance using an expert systems approach.

6.2.3 DIMENSIONS OF INTEREST. There are three dimensions of each domain information element that are essential to understanding the impact of that element on domain performance and expert systems supportability. These three dimensions are frequency, criticality, and difficulty. When preparing any type of analysis tool, be it a task analysis, job analysis, or other, the frequency of occurrence and criticality of the particular item are generally examined. These two measures are reliable indicators of the significance of the attribute to the overall system being analyzed. Estimates of frequency and criticality of an attribute provide a basis for decisions regarding the impact of the attribute on performance.

Item difficulty is an indicator of the complexity and ambiguity inherent in the domain context. Within DSAT, each domain information element question provides generic examples of three levels (low, moderate, and high) of difficulty for that element. These examples serve as anchors on the rating scale. The domain expert selects the example that most closely approximates activities in his domain, which provides an estimate of the complexity and ambiguity of the information context for that information element. Therefore, item difficulty can possess one of three values.

In the DSAT, a five-point Likert rating scale is used to evaluate the frequency and criticality of separate information components. Ranging from 1 (highly infrequent or highly noncritical) to 5 (highly frequent or highly critical), the scale allows the domain expert to provide a rating of the information component relative to its occurrence and impact on goal achievement. Items that are more frequent and critical will have higher scores than those items that are less frequent and critical. Higher scores imply higher significance in achieving successful outcomes in the domain. Refer to Appendix A for a description of the DSAT questionnaire.

7.0 METHODS AND RESULTS

This section presents the results of this effort: the method of data presentation, the domain suitability index calculation algorithm and scale, and the analysis of the reliability of the DSAT questionnaire.

7.1 DOMAIN DATA PRESENTATION. The DSAT gathers a large volume of complex information that cannot be easily assimilated in its raw form by the domain investigator. Therefore, a suitable means of organizing and displaying the data to convey meaningful information and allow interpretations of the salient information elements of the domain was developed. Appendices B1 and B2 contain the entire output generated for the domain of debugging a non-complex, small computer program.

7.1.1 ORGANIZATION. The dominant emphasis of the data reduction strategy employed centers around combining related elements to provide the domain investigator with useful information about the nature of the domain. Therefore, the data gathered by DSAT is organized in increasingly higher levels of abstraction which provide a corresponding level of domain understanding.

7.1.1.1 BENEFITS OF DATA REDUCTION. The benefit of reducing data is to a make a large volume of data more suitable for interpretation. Simply looking at the Level 0 data matrix provides little insight into the overall focus of a domain. The Level 1 graphs provide some indication of the more important information elements (contents) required by each of the domain operators. The Level 2 graph provides a more focused view of all the domain information elements grouped by the relevant operators involved in the domain. The Level 3 graph depicts an overall index for each operator and provides a single rating describing the applicability of that domain to techniques of expert systems.

7.1.1.2 COSTS OF DATA REDUCTION. The ratings gathered by the DSAT are simply averaged based on the number of information elements selected to arrive at the Level 1 and 2 graphs. Averaging, however, loses some of the information inherent in the raw data (at this time, simple averages of the specified information elements have been selected pending further investigation of possible weighting algorithms or other strategies of reducing the data). We have attempted to mitigate this loss of information by providing the Level 0 data matrix and by presenting the number of information elements comprising the ratings depicted in the Level 1 and 2 graphs. If the domain investigator questions any Level 1 or 2 presentation, he or she can review the Level 0 data matrix to ascertain the exact information elements composing the graph in question.

7.1.1.3 LEVELS OF ANALYSIS. In analyzing the data gathered by DSAT, four levels of analysis are used. Level 0 data is simply the domain information element ratings of frequency, criticality, and difficulty converted to a common 10-point scale. Level 0 data are classified by both operator and content-product categories. Included in the Level 0 presentation is the number of elements specified for each content category. Appendix B1 depicts the Level 0 data matrix for the debugging domain example.

The Level 1 analysis averages the frequency, criticality, and difficulty ratings individually across products for each content category for all specified information elements. This data is then graphed for each relevant domain operator (see Appendix B2 for Level 1 presentations). This allows the domain investigator to examine the relative importance of each content category to the particular operator in the domain.

The Level 2 analysis presents the averaged frequency, criticality, and difficulty ratings across all content-products for a specific operator in the domain (see Appendix

B2). This presentation allows the domain investigator to focus on the operators critical to domain performance and to understand the associated frequency and difficulty of those operators. The number of relevant information elements for each operator (with a possible total of 30) is also displayed to permit inferences regarding the extent of the operator's impact on the domain.

The Level 3 analysis combines the ratings of operator frequency, criticality and difficulty with the number of elements indicated to arrive at an overall operator rating for the domain. These operator ratings are then combined to obtain the domain suitability index which describes the degree of compatibility of expert systems technology and the information requirements of the domain. Section 7.2 describes the rationale for each factor of the domain suitability index.

7.1.2 **DSAT IMPLEMENTATION.** This section describes the procedures and results obtained (Appendices B1 and B2) for the domain of debugging a non-complex, small computer program. This domain was selected because it is highly constrained and the applicability of expert systems has already been established. The goal was to determine if DSAT could provide a domain assessment consistent with established knowledge of the domain information elements in order to establish some degree of concurrent validity.

The DSAT was administered to a domain expert (nine years of software programming and debugging experience) following the directions provided in the DSAT. The experimenter played the role of knowledge engineer and explained the background and intended use of the DSAT. After the domain expert completed Part I of the DSAT, the experimenter deleted all questions regarding the non-applicable elements in Part II. The domain expert then completed the ratings required in Part II. The entire interview process lasted approximately 75 minutes.

Appendix B1 describes the Level 0, 2, and 3 Data Summaries. The Level 0 data matrix immediately reveals that auditory and behavioral information is not included in this domain. Also of interest is the relatively equal inclusion of all operators in the domain in terms of number of information elements (57 total out of a possible 150) specified.

The Level 1 graph (shown in Appendix B2) for the cognition operator describes the data for 13 information elements. The visual and symbolic contents appear to be the most critical and frequent for this operator. The cognition operator primarily deals with discovery and recognition of various forms of information (Meeker, 1969). The combined emphasis on the visual and symbolic contents are indicative of how (using the eyes) domain experts gather (primarily symbolic) domain information. The high criticality of the visual content supports this interpretation, since this is the primary means of information input for humans. An exit interview with the domain expert confirmed this assumption.

The Level 1 graph for the memory operator describes a fairly even, fairly high (relative to other operators) emphasis on both the symbolic and semantic information contents. Memory, which is the storage or retention of information for later use (Meeker, 1969), in this domain is only concerned with the impact of particular symbols used and the meaning implied by those symbols. The elements, while fairly critical in nature are of a low difficulty level (which is consistent for all operators).

The Level 1 graph for the divergent production operator describes again, a fairly equal, but low emphasis on the symbolic and semantic contents of the domain. The lower criticality and frequency ratings indicate that the divergent production operator, which is generally associated with creative thought (Guilford, 1967), is not of high importance to this domain.

The Level 1 graph for the convergent production operator describes a similarly low, but slightly greater overall emphasis on the symbolic and semantic contents than the divergent production operator. This suggests a slightly greater reliance on rules and proceduralized or systematic solution of problems. This is expected in a domain where specific faults (bugs) often have specific remedies. The criticality and frequency of occurrence for this operation are moderately high (relative to other operators) suggesting some reliance on this operation. Based on the graphic representation of her responses, the expert has perceived rule-based solution strategies to be of more value than creativity for this domain.

The Level 1 graph for the evaluation operator describes a fairly high emphasis on symbolic contents with less on semantic contents. Again, this is expected since non-complex, well-defined computer software faults would tend toward errors of form (spelling, syntax, etc.) than errors of content (use of procedures, improper design of the software relative to the program goal, etc.). The evaluation operator appears to be of moderate significance in this domain.

The Level 2 graph for the 57 domain elements indicates a relatively higher domain criticality for cognition (the discovery or recognition of factors) which appears intuitively correct in a domain where discovering errors is of high priority. The memory operation is secondary in importance to cognition based on overall criticality and appears less frequently. Evaluation and convergent production are very similar, and while their frequencies and levels of difficulty do differ, there is little overall difference. Divergent production appears to be the least important to successful performance relative to the other operators in this domain.

Based on the Level 2 data, the expert's decreasing focus on the mental operators is in the following order: recognition (finding a possible bug), recall (storing and/or recalling the possible bug at the right time), and evaluation (is this really a bug?) and rule selection (now how do I fix it?) all at fairly low levels of difficulty appear to be intuitively correct for this domain. Overall, the information presented by DSAT appears to be highly correlated with the established understanding of the activities and information requirements of the debugging domain. Therefore, for this domain and level of DSAT refinement, these results indicate a fair degree of concurrent validity.

7.2 DOMAIN SUITABILITY INDEX. The Domain Suitability Index (DSI) correlates the domain information requirements with the capabilities of expert systems technology. By weighting the various dimensions and domain operators based on the relative supportability offered by expert systems technology, it may be possible to describe the domain with a single rating that can be compared to other domains, or used to estimate the success of adopting an expert system solution for the domain.

7.2.1 RATIONALE FOR DIMENSION WEIGHTING FACTORS. The weighting factors used for this analysis are only gross estimates of the possible "true" weights needed to accurately describe the supportability of expert systems and are implemented strictly as an exploratory approach. Future research must experimentally determine the true weighting factors.

There are two sets of weighting factors used: the dimensions (frequency, criticality, difficulty, and number of elements) and the operators (cognition, memory, divergent production, convergent production, and evaluation). The dimension factors will examined first.

7.2.1.1 DIMENSION FACTOR WEIGHTS . These factor weights (which sum to 1.0) translate the impact of information elements based on the dimension ratings collected by the DSAT. These weights are established by the degree of influence imparted by the dimension on the development of an expert system and the impact of the dimension in successful domain performance.

The dimension of difficulty defines the degree of ambiguity and complexity of an information element context and carries a weighting factor of 0.50. This is the highest weighted factor since this dimension is appears strongly correlated with high-risk expert systems implementations. That is, elements with high difficulty ratings are often not supported by expert systems techniques.

The next highest rated factor is criticality. Since this dimension indicates the relative importance of the information element to the domain, elements with high ratings should be included to insure successful domain performance. A factor of 0.35 is assigned to this dimension. The last two dimensions, frequency and number of information elements specified for a given operator, appear to be of little importance in terms of impact upon expert systems supportability. Therefore, frequency is assigned a factor of 0.10 and number of elements 0.05.

For example, a highly complex and critical, but infrequent, operator will have a greater impact on domain performance (and a correspondingly high demand for expert systems technology support) than a highly frequent, but less critical and complex operator. In summary, Equation 1 describes the model for the operator combined rating (OCR) score (which ranges from 0.0 to 10.0) of each operator based on the four dimensions weights:

$$OCR = 0.10^{*}(F) + 0.35^{*}(C) + 0.50^{*}(D) + 0.05^{*}(N). \qquad (1)$$

Where F is the Level 2 Frequency rating for the domain operator, C is the Level 2 Criticality rating for the domain operator, D is the level 2 Difficulty rating for the domain operator, and N is the number of information elements specified for the domain operator. Each of the frequency, criticality, and difficulty ratings and the number of elements are scaled to range from 0.0 to 10.0.

7.2.1.2 OPERATOR FACTOR WEIGHTS. The operator factor weights (which sum to 1.0) translate the support provided by expert systems technology for each operator in the domain. The sum of the weighted factors of the dimensions (each of the Operator Combined Rating scores) and the weighted-sum of those OCR scores is the domain suitability index (DSI) score for the domain. This score provides a measure of the suitability of the domain for expert systems technology. The following paragraphs explore the rationale for the weights of each OCR score.

The operator of divergent production is highly correlated with creativity and original thought, areas which are largely unsupported by expert systems technology. Therefore, this domain operator will have the greatest impact of all domain operators relevant to suitability for expert systems technology. To reflect this in the DSI score, the divergent production OCR score has a weight of 0.50.

The cognition operator deals with discovery and recognition of information. While some progress in pattern recognition and other machine "discovery" like functions have been developed, they are, at present, task specific and suggest a low-level of expert systems technology support. This OCR score carries a corresponding weight of 0.25 to indicate this questionable degree of support.

The evaluation operator is concerned with comparing and judging information against a standard or each other. To the extent that the rules for the comparison can be specified and the type of information being evaluated is suitable for machine analysis, this operator can be supported using an expert systems approach. Therefore, the OCR score for evaluation carries a weight of 0.15.

Memory, which involves storage and retrieval of information appears to be well supported by expert systems technology. While an important aspect of the memory operator is learning, or acquiring new knowledge (which is weakly supported by expert systems technology) it could argued this operator should carry a fairly high weighting factor. However, for this preliminary analysis, the memory OCR score will be carry a weighting factor of 0.05.

Convergent production, the operator that deals with following a set of rules to arrive at an answer, is viewed as being highly similar to the functionality of a rule-based expert system. Because of this functional similarity, the OCR score for this operator is also factored at 0.05.

Equation 2 summarizes the model of the Domain Suitability Index (DSI) score:

$$DSI = 0.25*(C\ OCR) + 0.05*(M\ OCR) + 0.50*(DP\ OCR) + 0.05*(CP\ OCR) + 0.15*(E\ OCR) \quad (2)$$

Where the value in parentheses is the relevant operator combined rating (OCR) score described in the preceding section.

7.2.2 ESTABLISHMENT OF DOMAIN SUITABILITY INDEX ANCHORS. To determine whether the DSAT questionnaire can provide an accurate estimate of suitability for specific domains, it is necessary to select at least two domains to serve as "anchors" to establish endpoints for the domain suitability index score (DSI). The anchor domains are selected based on existing knowledge of the domain suitability to expert systems technology. The domain selected for the lower anchor should be well-within the capabilities of expert systems technology and have several successful examples of expert systems in existence. The upper anchor domain should obviously be unsuitable for an expert system, perhaps requiring extensive understanding and creativity components for success.

Once the anchor domains are selected, the domain profile and accompanying DSI score can then be used to establish limits for the expected range of DSI scores for other domains. Finally, a domain is tested which should fall within the range provided by these two anchors. If the DSAT questionnaire is performing as desired, it should produce a domain profile and DSI score somewhere in between the domain anchors.

7.2.2.1 LOWER-BOUND DOMAIN ANCHOR. The domain chosen for the lower-bound anchor was debugging a non-complex, small (less than 200 lines of code) computer program with a specified function and inputs. Section 7.1.2 describes the rationale for choosing this domain and one domain expert's DSAT results. To summarize, the information requirements of this domain are fairly well known and several expert systems have been designed to perform the task (Frenkel, 1985) making this domain suitable as a lower bound anchor.

7.2.2.2 UPPER-BOUND DOMAIN ANCHOR. To be suitable as an upper-bound anchor for the DSI scale, a candidate domain requires extensive, possibly inarticulatable (deep as opposed to shallow) domain knowledge for achieving adequate performance. Other desirable features include a high degree of human interaction involved in data gathering, unambiguous and indeterminate levels of information used to make decisions, and a high degree of creativity or diverse alternatives required for high domain performance.

This short list should by no means be considered exhaustive, simply features of the nature of a domain that would be an extremely high risk venture from an expert systems perspective. For example, managing a large, multinational corporation, symphonic quality music composition, writing a novel, or coaching a football team are all examples where an expert system development program would probably have a high risk of failure.

With these examples in mind, the domain of developing a research proposal is selected. This domain requires a large degree of interpersonal data gathering, which includes a significant degree of interpreting behavioral actions to assess proper responses on the part of the proposal author. Also, the degree of creativity required in producing a proposal that is concise, yet "sells" the proposed research is often high for successful proposals. Successful proposal authors often demonstrate a deep understanding not only of their particular field, but of the proposal process and the politics of "shepherding" a proposal through the "gates" required for approval. Appendix C1 presents the Level 0-3 Data Summaries Appendix C2 presents the same data graphically.

It is obvious from the Level 2 Data Summary graph that a high level of emphasis is placed on the divergent production operator in this domain, with the operator level of difficulty at the maximum and criticality near maximum. The other operators also show significantly higher difficulty ratings than does the debugging domain. The DSI score for this domain was also fairly high at 7.2. While a higher DSI seems justified by the data display, it must be remembered that the DSI algorithm is only a gross estimate of what the true factors should be. Further research of how expert systems technology supports each of this domain operators is necessary to develop a truly accurate DSI scale.

The DSI scores for the two domains do, however, indicate the ability of the DSAT questionnaire to discriminate between domains of varying expert systems technology suitability. Based on the preliminary nature of the DSI algorithm and individual domain problem solving style of the domain experts, the scores of the anchor domains were not as diverse (ideally the debugging domain would be near 0.0 and the grant proposal domain would be near 10.0) as desired, but the scores do provide a useful indication that the DSAT methodology is fundamentally capable of discriminating between different domains.

7.2.3 TESTING AN UNKNOWN DOMAIN. Having established the lower- and upper-bounds of the DSI scale, a domain of possible, but unknown suitability for expert systems technology is tested. This domain should have elements of both anchor domains, but in an unknown combination. For example, the domain should have some degree of creativity associated with it, but also rely on the use of rules and have some information inputs be unambiguous and noncomplex. Other desirable domain features might include a requirement for behavioral information or significant use of evaluation or cognition operators using well-defined information.

Using these selection criteria, the domain of evaluating the mental capacities of children in grades K, 1, and 2 for entry into a gifted education curriculum was selected. The domain expert has 29 years in primary grade education and has been performing evaluations of this nature for 5 years. Appendix D1 contains the Level 0-3 Data Summaries and Appendix D2 has the graphic display of the data. As predicted, the DSI score for the domain was 5.2 which falls between the two scale anchor domains.

The operators of cognition and evaluation appear to most important in this domain. From the Level 2 graph (Appendix D2), the criticality of both cognition and evaluation are high relative to the other operators. This appears intuitive since the primary goals of the gifted education specialist in a session are to discover and recognize traits that characterize the student and then evaluate those traits against specified standards.

While the overall Level 2 difficulty is not extremely high, the Level 1 graph for the cognition operator shows a heavy reliance on auditory and behavioral, as well as symbolic information contents. While symbolic information contents are supported by expert systems technology, interpretation of auditory and behavioral information is only weakly supported. The Level 1 display therefore suggests that perhaps parts of this task may not be supported with an expert system.

The operator of evaluation also requires a wide range of content support. However, the lower levels of difficulty indicate that perhaps a large part of those evaluation tasks could be supported using an expert system. To the extent the evaluation rules could be represented, the majority of the evaluation function would be supported, relieving the domain expert to pursue other functions (such as cognition) that are more suited to the human's capabilities.

The preceding analysis shows the power of the DSAT approach. By determining the relevant domain information attributes, it is possible to make defensible decisions (by using the various Levels of data summary) regarding the allocation of those functions between the human and the system, based on the strengths and weaknesses of each. By allocating these necessary functions to the entity most capable to perform the task, the ultimate performance of the design is improved.

7.2.4 SUMMARY OF THE DSI SCALE. Figure 4 describes the anchor scores and the unknown domain score for the DSI scale. As the DSAT is used for diverse domains, the points along this scale will become better defined. Determining the cut-off points for varying levels of expert systems development risks will have to be established in future research. However, the basic value of the DSAT concept is confirmed, with the appropriate ranking of domains based on their established applicability for expert systems technology solutions.

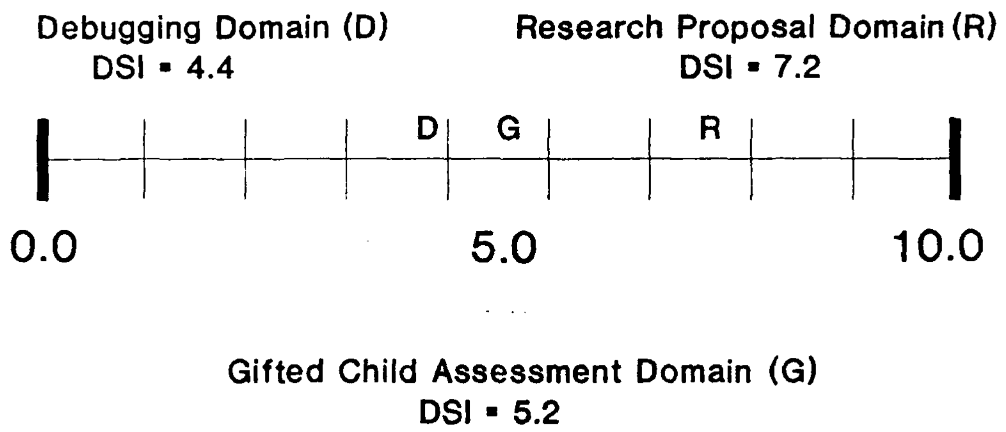

Figure 4. Domain Suitability Index Scale showing relative positions of anchor and unknown domains.

7.3 RELIABILITY OF DSAT QUESTIONS. This section describes the procedures and results of investigating the reliability of the DSAT questionnaire. The rationale for each aspect of the investigation is also described.

Reliability is examined from the standpoint of consistency of results among subjects of (assumed) similar experience levels rating the same task. Based on this basic experimental goal, the following sections will describe the measures of interest for this study, the experimental design, the method of data collection, the method of data evaluation, and interpretation of the results of the study.

7.3.1 MEASUREMENTS OF INTEREST. The key measurement of interest in this investigation is the variability among the ratings made by subjects. Due to the ordinal nature of the collected data, statistical analyses which require interval scales cannot be performed. Therefore, the standard deviation of each operator included in the domain analysis is selected as the estimator of variability among ratings from the domain experts. Smaller values of the standard deviation indicate a higher degree of agreement among domain experts for that operator with respect to the domain.

The DSAT uses a 10-point scale for comparing ratings across dimensions. Therefore, a standard deviation of ± 1.0 or less would be highly desirable, since 68% of the ratings for that element would fall within that range. However, due to the preliminary nature of this study, standard deviations of ± 2.0 or less indicate the DSAT is making useful discriminations among the various domain elements.

A secondary measure of interest is the range of responses for a given domain element. The interquartile range (the middle 50% of reported ratings for a specific element) is another indicator of the degree of agreement between domain experts regarding a particular domain element. For this study, an interquartile range of 3.0 or less has been selected as indicative a suitable "clustering" of ratings.

While the specific means of responses (i.e., the mean for the difficulty dimension for the cognition operator or the domain suitability index score) are of interest for measuring the DSAT's degree of content validity (does the tool measure what it is supposed to measure), they are not the focus of this evaluation. The preliminary nature of the DSI algorithm and the DSAT questionnaire both make evaluations of this particular measure premature. Later research devoted to establishing the validity of the tool will definitely focus on aspects of this nature.

7.3.2 EXPERIMENTAL DESIGN. The basic design of this analysis is the administration of the DSAT questionnaire to a ten experts in a domain, calculation of the standard deviations and ranges of the responses, and interpretation of those results with respect to the reliability of the tool based on the measures of interest described in the preceding section. Hypothesis 3 (described in Section 6.1) is tested in this analysis.

In this design, several assumptions are made regarding the data (the ratings collected) and subjects. The data is assumed to be ordinal in nature, limiting the types of statistical analyses that can be used to simple univariate descriptors such as mean, standard deviation, and skewness. The data is also assumed to be normally distributed and independent of the level of experience of the subject. Therefore, subjects should report the same basic scores regardless of their level experience for the given domain task.

Subjects are assumed to be homogeneous, in that their level of experience with the task and the underlying foundations of the DSAT tool are similar. The order of the questions presented in the DSAT (such as the contents within Part I or the operators in Part II) is also assumed to have no effect on subjects' ability to rate dimensions of frequency, criticality, difficulty, and number of elements in the domain. It is assumed that the wording of the domain examples will impact the subjects' ability to determine the difficulty rating and is a major focus of this study.

7.3.3 DATA COLLECTION. The basic premise of the study was to administer the DSAT as it would be used in the field; administered by a knowledge engineer who sought information about a specific domain from a domain expert. Debugging a non-complex, small computer program with a specific function was selected as the domain of interest since this domain has been implemented to some extent (Frenkel, 1985) using expert systems technology (therefore some knowledge of the domain's suitability for expert systems has been established) and the availability of subjects with domain expertise was high.

Subjects were selected based on prior experience in performing software debugging tasks. Subjects' experience ranged from 5 to 19 years, with a mean of 9.8 years. After the experimenter explained the purpose of the study, the domain of interest, the subject's role, and answered any questions, the subject completed the informed consent form (shown in Appendix E).

Part I of the DSAT questionnaire (see Appendix A) was first presented to the subject. As described in Section 6.0, Part I of the DSAT is provided to allow the domain expert to define the content-products relevant to the domain to reduce the number of Part II questions to a manageable size and to become acquainted with the terminology and format of the DSAT before actual ratings are made. As the subject completed each section of Part I, the experimenter tailored the Part II questions by crossing-out content-products not specified by the domain expert.

The domain expert completed Part II by evaluating the frequency, criticality, and level of difficulty of each domain relevant operator with the content-product elements specified in Part I. If a particular content-product specified in Part I was not relevant for a specific operator in Part II, the domain expert left the question blank. All domain experts were able to complete both Parts I and II between 75 and 110 minutes. Upon completion, subjects were asked their number of years of experience of computer programming.

At the conclusion of each session, the experimenter entered the subject's level of experience and domain responses into a computerized spreadsheet program to produce the DSAT Level 0 Data Summary (see Appendix F). Each rating of frequency and criticality was multiplied by 2.0 and difficulty ratings were multiplied by 3.33 prior to data entry. By using these factors (2.0 for the 5-point scale and 3.33 for the 3-point scale) it was possible to put all three scores on a comparable (10-point) scale for later data analysis.

Since the Level 0 represents the data in its most basic (and difficult to interpret) form, the DSAT Level 2 Data Summary (also shown in Appendix F) was used as the basis for the data analysis. While Level 0 data holds the most information, the sheer volume of data points makes the data analysis and interpretation of the results more difficult. However, Level 3 Data, which significantly reduces the number of data points to be analyzed, is based solely on the algorithm factors which have not been rigorously established. Any inferences made from Level 3 Data would have to be treated with caution. The Level 2 Data, which averages the dimensions of frequency, criticality, and difficulty over the content-products for each operator, provides the best compromise between parsimony and information content.

7.3.4 METHOD OF DATA EVALUATION. As described in Section 7.3.1, the basic objective of the study was to determine the degree of variability among domain experts for rating a specific task. Using the Statistical Analysis Software (SAS), the Level 2 Data for all 10 subjects was analyzed (see Appendix G for SAS program).

Twenty-three data points for each subject were used from the Level 2 Data Summary, and are described in Table 6. The raw data of Appendix F was entered into the data analysis program. Table 7 lists a summary of the univariate outputs for each of the variables listed based on all 10 subjects.

7.3.5 DATA INTERPRETATION. The variability for frequency, criticality, and difficulty measured by the standard deviation was less than 2.0 for 11 of these 15 variables as shown in Table 7. The interquartile ranges were similarly within the desired range. This indicates a fairly high degree of agreement among the domain experts for these variables. However, the standard deviations reported for the

TABLE 6

Summary of Level 2 Data Points Used (*) in Analysis

DIMENSIONS

OPERATORS	FREQ	CRIT	DIFF	NUMR	OCR	
COGNITION	*	*	*	*	-	
MEMORY	*	*	*	*	-	
DIVERGENT PRODUCTION	*	*	*	*	-	
CONVERGENT PRODUCTION	*	*	*	*	-	
EVALUATION	*	*	*	*	-	
	-	-	-	*	*	= DSI

LEGEND: Abbreviation = Dimension (Range of Values)

FREQ = Frequency Rating (0-10)

DIFF = Difficulty Rating (0-10)

CRIT = Criticality Rating (0-10)

NUMR = Number of Elements Rated (0-30/3)

OCR=Operator Combined Rating Score (0-10), weighted average of dimension ratings (See Equation 1).

DSI=Domain Suitability Index Score (0-10), weighted average of operator combined rating scores (See Equation 2).

TABLE 7

Summary of Means, Standard Deviations, and Interquartile Ranges for DSAT Reliability Study (N = 10)

OPERATORS		FREQ	CRIT	DIFF	NUM
		DIMENSIONS			
COGNITION	Mn	6.390	7.390	6.080	14.000
	SD	0.950	0.823	1.834	1.885
	IR	1.250	1.575	2.275	2.500
MEMORY	Mn	5.550	6.370	5.610	13.000
	SD	1.396	1.133	1.978	3.623
	IR	1.400	2.050	2.225	3.250
DIV. PRO.	Mn	4.990	6.140	4.870	8.500
	SD	2.489	2.663	2.301	5.949
	IR	2.125	2.525	3.175	10.500
CON. PRO.	Mn	5.020	5.970	5.200	11.700
	SD	1.149	1.180	1.938	3.401
	IR	1.600	2.225	2.975	4.000
EVALUATION	Mn	5.440	5.860	5.220	13.200
	SD	0.530	0.802	2.164	3.225
	ID	0.500	0.925	2.525	4.500
DSI	Mn	5.980	NUMR	Mn	60.400
	SD	1.360		SD	13.049
	IR	2.175		IR	11.000

LEGEND: Abbreviation = Term

DIV. PRO = Divergent Production

CON. PRO.= Convergent Production

DSI = Domain Suitability Index Score (See Equations 1 and 2.)

NUMR = Number of Elements Selected

Mn = Mean

SD = Standard Deviation

IR = Interquartile-Range

frequency, criticality, and difficulty ratings for the divergent production operator were over 2.0. This indicates some degree of disagreement between domain experts regarding this operator.

Also, the dimension with the greatest variability (highest standard deviations) was the difficulty dimension. The difficulty dimension was originally predicted to be the largest contributor of variation among domain experts (see Section 7.3.2). It is possible that these examples may need revision to reduce the variability among respondents.

There is another factor that may be responsible for the large variation among domain experts in the difficulty dimension. During the course of the study, several of the overall ratings given by some subjects appeared to be significantly different from the rest of the group. Looking at Table 8 (Subject Selected Raw Data Summary), it appears that subjects who reported more years of experience tended to have higher difficulty ratings and higher domain suitability index (DSI) scores.

This raw data suggests that experience influence how subjects perceive their domain. Further correlational and ANOVA analyses of the data indicates there is a significant effect for experience. This effect of experience on DSAT-derived ratings of difficulty in general and the divergent production operator in particular are the most important (and unexpected) findings of this research. While it was suggested that some effect due to individual problem solving strategies would be evident in the DSAT results, the strength of the differences due to experience level was unanticipated.

Table 9 presents a summary of the correlation data used to assess the effect of experience based on data taken from all 10 subjects. Experience was found to correlate (some at highly significant levels) with reported ratings of difficulty in general and divergent production in particular. This high correlation of level of expertise with the mental operation of producing many alternatives for a given condition supports findings by Chiesi, Spilich, and Voss (1979). According to their research, experts consistently generated more and better

TABLE 8

Summary of Selected Raw Data Ratings from DSAT Reliability Study Indicating an Effect Due to Experience

SUBJ NUM	EXP	COG-DIFF	MEM-DIFF	CVP-DIFF	EVL-DIFF	DVP-DIFF	DVP-FREQ	DVP-CRIT	DSI
1	2	4.1	3.3	3.6	3.3	3.3	4.4	4.6	4.8
2	2	3.7	3.3	3.3	3.3	3.3	5.0	7.0	4.9
5	2	6.5	6.3	6.0	5.6	5.6	3.6	6.4	6.3
6	2	6.1	5.6	4.2	4.0	0.0	0.0	0.0	3.3
9	2	5.7	4.7	3.6	4.4	3.9	5.4	5.7	5.2
3	1	5.3	4.9	4.6	4.3	6.7	10.0	10.0	6.9
4	1	6.2	5.5	5.1	4.3	5.6	6.1	7.7	6.7
7	1	8.7	7.4	8.8	9.6	6.4	4.1	5.6	7.2
8	1	5.0	5.1	4.5	4.8	5.8	6.1	8.4	7.0
10	1	9.5	10.0	8.3	8.6	8.1	5.2	6.0	7.5

LEGEND: Abbreviation = Term

SUBJ NUM = Subject Number

EXP = Subject's Years of Experience

COG-DIFF = Cognition Operator Difficulty Rating

MEM-DIFF = Memory Operator Difficulty Rating

CVP-DIFF = Convergent Production Operator Difficulty Rating

EVL-DIFF = Evaluation Operator Difficulty Rating

DVP-DIFF = Divergent Production Operator Difficulty Rating

DVP-FREQ = Divergent Production Operator Frequency Rating

DVP-CRIT = Divergent Production Operator Criticality Rating

DSI = Domain Suitability Index Score (See also Equations 1 and 2.)

NOTE: Subjects with EXP => 10 years are in Group 1; subjects with EXP < 10 years are in Group 2.

TABLE 9

Summary of Correlations Between Experience and the Difficulty Dimension, the Divergent Production Operator, and DSI Score

	COG-DIFF	MEM-DIFF	CVP-DIFF	EVL-DIFF	DVP-DIFF	DVP-FREQ	DVP-CRIT	DSI
Rho -	0.537	0.609	0.507	0.498	0.715	0.464	0.372	0.658
Level of Significance -	0.109	0.062	0.134	0.143	0.020	0.177	0.290	0.039

LEGEND: Abbreviation = Term

COG-DIFF = Cognition Operator Difficulty Rating

MEM-DIFF = Memory Operator Difficulty Rating

CVP-DIFF = Convergent Production Operator Difficulty Rating

EVL-DIFF = Evaluation Operator Difficulty Rating

DVP-DIFF = Divergent Production Operator Difficulty Rating

DVP-FREQ = Divergent Production Operator Frequency Rating

DVP-CRIT = Divergent Production Operator Criticality Rating

DSI = Domain Suitability Index Score (See also Equations 1 and 2.)

NOTE: Rho is the correlation coefficient and Level of Significance is the probability of getting a higher value of Rho by chance alone.

(relative to goal achievement) alternatives for a given set of conditions.

Chiesi, et al. determined that experts also tended to show very little variation in their responses to a given situation. That is, the mental models of the experts appeared to be converging. It is interesting to note that the standard deviation for the DSI score of Group 1 (expert) subjects was 0.305, while Group 2 (novice) subjects was 1.075, which indicates that experts shared a greater similarity in their perception of the domain than did novices. Also, the difference in mean DSI scores for thetwo groups was significantly different at the 0.0025 level (see Table 10).

Chi, Glaser, and Rees (1981) also report similar findings. Experts in their study were able to give more accurate estimations of problem difficulty than novices. Experts all recognized the basic underlying concepts of the problems which allowed the more accurate estimates, while novices could only focus on the surface level attributes of the problem, making their difficulty estimates less accurate. This statement is supported by the higher variation among novice DSI scores.

There are several implications of the results of the DSAT reliability study. First, the results indicate the DSAT questionnaire is fairly reliable based on the examination of the measures of interest presented above. Next, the sensitivity of the DSAT (even in its current, unrefined format) to differences in levels of expertise and concurrence of these results with other research supports the validity of the tool. Finally, the results of this study suggest the DSAT questionnaire will have a positive role in future research activities related to cognitive engineering and knowledge acquisition as well as assessing domain suitability for expert systems technology.

TABLE 10

ANOVA Summary Table for Comparing DSI Means Based on Experience Level

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	OBSERVED F-STATISTIC
EXPERIENCE	1	11.6640	11.6640	18.69
ERROR	8	4.9920	0.6240	
TOTAL	9	16.6560		

R SQUARE = 0.7003 PR > F = 0.0025

8.0 FUTURE RESEARCH

There are still several areas to be addressed by future research to fully develop the DSAT. These include development of an empirically established domain suitability index (DSI), refinement and validation of the DSAT as an operational tool, and other application areas such as knowledge acquisition, definition of the user's mental structuring of the task, determination of the functional allocation of duties between the human and the system, and identification of areas of expert systems technology requiring additional research.

8.1 DEVELOPMENT OF THE DSI ALGORITHM. Perhaps the most difficult and important step to achieving the original goal of DSAT is the development of an empirically established algorithm for producing a domain suitability index score that accurately reflects the capabilities and limitations of expert systems technology relative to the elements specified in the SOI model. The DSAT currently provides a useful description of the domain; a validated algorithm will provide high confidence in the recommendations of the domain suitability index score.

8.2 REFINEMENT OF DSAT. Continued refinement of the DSAT questionnaire and administrative procedures will increase the reliability of the data collected and quality of that data. One potential area of research involves the development of more specific domain examples that may increase the domain expert's ability to recall activities in the domain. Examination of the expected benefits of this more focused approach balanced against the costs of producing a number of domain-specific questionnaires would be useful.

A related area of research is the implementation of an automated DSAT. Using the power of the computer coupled with a hypertext format, the DSAT is envisioned as moving from a paper and pencil questionnaire to a computer-supported aid for knowledge acquisition and domain evaluation. Supporting the DSAT entirely via the interactive computer will enhance both the speed of data collection and the range of domain experts that can be interviewed thereby providing better domain coverage. This accumulation of data from different sources could allow the knowledge engineer to develop a better understanding of the domain.

Adaptation of the DSAT to allow comparison of existing expert systems for a given domain is another necessary topic for future research. The utility of having a common standard of comparison for two (or more) expert systems for a particular application appears to be high. Some work is necessary to modify the data reduction/analysis used in the current tool to account for the different expert systems (perhaps different domain suitability index weighting factors based on the strengths of the particular expert system).

As the DSAT is used for increasingly diverse domains, data must be collected to establish its true validity as a domain evaluation tool. Data regarding the outcomes of expert systems development programs and the initial recommendations of DSAT can be used to establish this validity. Also, subjective data from both domain experts and knowledge engineers can be collected to refine the DSAT and document its operational utility.

8.3 OTHER APPLICATIONS OF DSAT. There are several possible applications of the domain definition capabilities of the DSAT methodology. Future research should address the role of DSAT in knowledge acquisition, cognitive engineering, functional allocation, and identification of expert systems technology areas requiring additional research.

8.3.1 KNOWLEDGE ACQUISITION. A possible role for DSAT may be in the area of knowledge acquisition. The domain representation gleaned from a DSAT analysis could be a useful aid in focusing the activities of a knowledge engineer during the knowledge elicitation process. The Level 2 display of the gifted child assessment domain, (which showed cognition and evaluation as leading operators) for example would suggest questions regarding how the specialist discovers and recognizes traits in an individual and then how those traits are evaluated.

The benefit to knowledge engineers is that with comparatively small investment of resources, the DSAT provides a fast method of determining what areas of the domain are critical and difficult in the domain. This knowledge is particularly useful when the knowledge engineer is pursuing a domain with which he is unfamiliar. Taking a rudimentary domain understanding, DSAT is able to highlight the areas of greatest domain importance, allowing the knowledge engineer to proceed immediately to the "high payoff" aspects of the domain. This can save time and money in the development of the system by reducing the impact of the "knowledge acquisition bottleneck."

8.3.2 COGNITIVE ENGINEERING. The field of cognitive engineering (see Woods and Roth, 1988) which seeks to develop a principle-driven, applied cognitive science based on the fundamentals and theories of cognitive psychology and other related fields, could also benefit from the DSAT methodology.

A key challenge for cognitive engineering is developing a method of identifying the foundations of expert task performance (Gitomer and Glaser, 1987). The studies of Chi, et al. (1981) and others have clearly shown that experts perform at high levels due to different methods of organizing specific elements of domain knowledge (Roth and Woods, 1988). The supporting results obtained during the DSAT reliability analysis indicate the potential usefulness of DSAT for describing how an expert structures domain-specific knowledge.

Based on the potentially high contribution the DSAT methodology can offer in describing the structure of domain-specific knowledge, further studies investigating the utility of DSAT for these and other cognitive engineering and cognitive science related research should be pursued.

8.3.2 FUNCTIONAL ALLOCATION. By specifying the relevant operations and information contents of the domain, DSAT allows a rapid and accurate comparison of both system strengths and weaknesses, as well as user strengths and limitations. With an understanding of the essential domain information attributes, the entity (man or machine) best equipped to support and deal with that information element can be assigned responsibility for that element in the overall system design. The resulting allocation of functions (tasks) between user and (expert) system will result in the greatest level of overall system effectiveness and performance.

8.3.3 IDENTIFICATION OF EXPERT SYSTEMS RESEARCH TOPICS. Finally, domains that score high on the DSI scale can be examined to determine what domain information elements make them unsuitable candidates for expert systems technology solutions. The common traits of these domains can be specified to define unsupported activities. Expert system designers, cognitive engineers, software designers, human factors engineers, and artificial intelligence scientists can then investigate alternative means for developing technology to implement these activities in future expert systems.

9.0 CONCLUSIONS

The are several important general conclusions to be drawn from this research. First, the field of expert systems can benefit from the inclusion of basic principles of human cognition in the selection of potential application domains. Second, development and application of a principle driven design approach for building expert systems can not only reduce the resources required to achieve a working system, but also will ultimately result in a better accepted, more capable system that meets the performance objectives of the project. Third, theories of human intelligence can be successfully applied to varying domains to define the information requirements of those domains and provide decision-makers with useful knowledge of the domain's suitability for an expert systems technology solution.

There are also several important specific conclusions to be drawn from this research. The working hypotheses of this research are (see Section 6.1):

Hypothesis 1:

The DSAT will provide a description of the information types and processes used for performance of domain tasks by the human expert.

Hypothesis 2:

The DSAT will be easily administered, analyzed, and interpreted.

Hypothesis 3:

The DSAT will possess a high degree of reliability for describing domain information requirements.

Hypothesis 4:

The DSAT will possess a high degree of validity for describing domain information requirements.

The DSAT implementation and results described in Section 7.1 suggest the DSAT methodology is capable of obtaining domain information and discriminating between different domains. This indicates support for accepting Hypothesis 1, that the DSAT is useful for examining human task domains.

Acceptance of Hypothesis 2 is also supported since these results suggest the DSAT methodology gathers domain information quickly and presents domain data in a readily understandable format, lending itself to ease of application by practitioners.

The results described in Section 7.3 indicate the DSAT (in its current form) is fairly reliable for most domain information elements, suggesting support for accepting Hypothesis 3. Additional refinement of the tool is needed to improve the reliability of the divergent production operator and difficulty dimension ratings.

While not formally addressed in the experimental design of this research, some support of acceptance for Hypothesis 4 was also determined. Based on the similar findings of other researchers identified in Section 7.3.5., some concurrent validity for the DSAT can be inferred. Also, by virtue of using an established theory, the methodology has a high degree of construct validity.

While the Domain Suitability Assessment Tool's goal of a complete domain assessment methodology has not yet been totally achieved, the critical first steps have been successfully taken. A methodology, with its foundation in an established theory of cognition, has been developed and demonstrated as a reliable means of defining the information requirements of a domain. It is now possible to pursue development of an accurate translation of those domain information requirements into meaningful estimates of the degree of support provided by current expert systems technology.

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APPENDICES

APPENDIX A. DOMAIN SUITABILITY ANALYSIS TOOL QUESTIONNAIRE

APPENDIX A

DOMAIN SUITABILITY ANALYSIS TOOL (DSAT) INSTRUCTIONS AND QUESTIONNAIRES

Part I. ASSESSMENT OF DOMAIN STRUCTURAL COMPONENTS

The following 5 sections of 6 questions examine the information content of the domain under consideration. First, examine the section title and accompanying description. If the type of information described is evident in the domain, proceed to each question in that section, answering "yes" or "no." Answer "yes" if the example of the information element occurs in the domain, and "no" if it does not. If you are unsure about an item, answer "yes;" you will be able to examine it more thoroughly in Part II. After you have examined all 5 sections, and answered the applicable questions, proceed to Part II.

SECTION 1. VISUAL CONTENTS. To perform successfully in this domain, is it necessary to see and process items of a visual nature, such as trees, parts, faces, buildings, or other objects that can be immediately perceived or comprehended as visual forms? For example, in the domain of diagnostic medicine, a doctor must be able to process information such as the physical symptoms (swelling, discoloration, skin rash, etc.), and general condition through primarily visual means.

YES____ (answer remaining questions) NO____ (proceed to next section)

YES - NO

___ - ___ A. VISUAL UNITS. Any single item with a unique identity. Examples: a word, a silhouette, a universal product code symbol, a dot, an aircraft.

___ - ___ B. VISUAL CLASSES. Classification of images into related groups. Examples: red items, biplanes, cubist art, deciduous trees, printer fonts.

___ - ___ C. VISUAL RELATIONS. A logical connection between two images. Examples: one girl taller than another, similarities of Porsche and Corvette body styles.

___ - ___ D. VISUAL SYSTEMS. Three or more items composing a collective whole. Examples: the placement of 22 football players before a play, the positions of all aircraft waiting in a holding pattern.

___ - ___ E. VISUAL TRANSFORMATIONS. Modification of an existing image into another form. Examples: visualizing the rotation of an object by 270 degrees, imagining how a landscape seen in the summer appears in the winter.

___ - ___ F. VISUAL IMPLICATIONS. Foreseeable consequences evidenced by the current visual state. Examples: seeing a brown apple and knowing not to eat it, seeing a red light and stopping.

SECTION 2. AUDITORY CONTENTS. Does successful performance depend on the ability to perceive or comprehend information of an auditory nature, such as verbal commands, warning tones, music, or interpretive noises (like the hum of a well-tuned engine, the squeal of a loose fan-belt, or other sounds indicating things are "right" or "wrong")? In the diagnostic medicine example, the doctor must hear the patient's heartbeat, air filling the lungs, and the patient's own comments to arrive at an accurate diagnosis.

YES____ (answer remaining questions) NO____ (proceed to next section)

YES - NO

___ - ___ A. AUDITORY UNITS. A single sound with a unique identity. Examples: a musical note, a spoken word, a dog's bark, a car horn.

___ - ___ B. AUDITORY CLASSES. Classification of sounds into groups. Examples: words with the "oo" sound, loud sounds, ragtime tunes, rock and roll music.

___ - ___ C. AUDITORY RELATIONS. Logical connections between two sounds. Examples: two tones an octave apart, a waltz compared to a march, a cannon being louder than a rifle.

___ - ___ D. AUDITORY SYSTEMS. Three or more sounds integrated to form a unique whole. Examples: a melody, a rhythm, the phonetic alphabet (ALPHA, BRAVO, CHARLIE, DELTA, etc.).

___ - ___ E. AUDITORY TRANSFORMATIONS. Modification of an existing sound or pattern. Examples: a jazz solo based on the original melody, disguising one's voice.

___ - ___ F. AUDITORY IMPLICATIONS. Information suggested by a given sound. Examples: hearing a bell and knowing class is over, hearing brakes screech and bracing for impact.

SECTION 3. SYMBOLIC CONTENTS. Does the human operator need to understand or process information of a symbolic nature? Symbols, such as a letter, number, musical note, or a "$" are arbitrary items that have no intrinsic significance, until placed in a specific context. The doctor consults a variety of charts, instruments, and other symbolic representations of the patient's state when performing diagnosis of the patient's symptoms.

YES____ (answer remaining questions) NO____ (proceed to next section)

YES - NO

___ - ___ A. SYMBOLIC UNITS. A single item with a unique identity. Examples: a plus (+) sign, a tank silhouette, a square, a Cyrillic letter, the Statue of Liberty.

___ - ___ B. SYMBOLIC CLASSES. Classification of symbols into groups. Examples: mathematical symbols, Arabic numerals, military rank insignia, national flags.

___ - ___ C. SYMBOLIC RELATIONS. Logical connections between two symbols. Examples: "6" is greater than "5," a silver star (general) outranks a silver eagle (colonel).

___ - ___ D. SYMBOLIC SYSTEMS. Three or more symbols composing a collective whole. Examples: telephone numbers, words, stop lights (red = stop, yellow = caution, green = go).

___ - ___ E. SYMBOLIC TRANSFORMATIONS. Modification of an existing symbol or set of symbols. Example: rearranging scrambled letters into words, converting written words into their audible counterparts when reading aloud.

___ - ___ F. SYMBOLIC IMPLICATIONS. Information suggested by a given symbol. Examples: if a given symbol is a friendly or enemy aircraft, if ADV stands for "advance" or "adversary," if "*" means multiply or divide.

SECTION 4. SEMANTIC CONTENTS. Is it necessary to maintain a repertoire of words and ideas that carry an abstract meaning that are immediately comprehended when the stimulus is perceived? Semantic contents pertains to information in the form of an idea or mental image. Meaningful pictures, words, and verbal communication are examples of this concept. For example, a patient relates he has a "burning sensation" in his lower-right portion of his abdomen. To the doctor, these words strongly suggest appendicitis.

YES____ (answer remaining questions) NO____ (proceed to next section)

YES - NO

___ - ___ A. SEMANTIC UNITS. Single ideas or concepts. Examples: the meanings of words, the sound of a particular musical note, a baseball player's batting average.

___ - ___ B. SEMANTIC CLASSES. Groupings of similar concepts. Examples: kinematic equations of motion, musical scales, farm animals, types of viruses, styles of architecture.

___ - ___ C. SEMANTIC RELATIONS. Connections logically made between two concepts. Examples: tie between bond prices and interest rates, correlation of height and weight.

___ - ___ D. SEMANTIC SYSTEMS. Three or more integrated concepts composing a complex whole. Examples: a story, the rules of tennis, objects on a radar screen, English language.

___ - ___ E. SEMANTIC TRANSFORMATIONS. Potential changes of interpretations of objects and situations. Examples: design changes needed to meet new specifications, a court decision based on new evidence.

___ - ___ F. SEMANTIC IMPLICATIONS. Consequences or outcomes suggested by specific concepts. Examples: repercussions of unilateral disarmament, fiscal policy decisions based on the leading economic indicators.

SECTION 5. BEHAVIORAL CONTENTS. To perform successfully in this domain, is the perception and understanding of human attitudes, needs, moods, ideas, and intentions required? These information elements are primarily evident in domains involving human interaction, but can be required for individual activities. To illustrate, our diagnostic physician will attempt to gauge the patient's physical state by noting the patient's alertness, tone of voice, moodiness, and other exhibited behaviors.

YES____ (answer remaining questions) NO____ (proceed to Part II)

YES - NO

___ - ___ A. BEHAVIORAL UNITS. Single elements of expression. Examples: a frown, a wink, laughter, posture, gestures, tone of voice.

___ - ___ B. BEHAVIORAL CLASSES. Groupings of similar expressions. Examples: happy faces, depressed body postures, aggressive gestures.

___ - ___ C. BEHAVIORAL RELATIONS. Connections between behaviors based upon social understanding. Examples: waving when you say good-bye, shaking hands when you are introduced.

___ - ___ D. BEHAVIORAL SYSTEMS. Relevant behaviors comprising a social situation. Examples: social etiquette, acceptable conduct on the football field, Washington "VIP" protocol.

___ - ___ E. BEHAVIORAL TRANSFORMATIONS. Changes in the behavioral significance of a given situation. Example: negative stereotypes held about a racial group changing to positive feelings after interacting with members of the group.

___ - ___ F. BEHAVIORAL IMPLICATIONS. Foreseeable consequences of a given set of social behaviors. Examples: kicking dirt on an umpire's shoes results in ejection from the game, constantly belittling an employee results in building resentment and eventually the employee quitting.

Part II. ASSESSMENT OF OPERATIONAL COMPONENTS

Based upon the answers provided in Part I, Part II seeks to identify the mental operations that occur in processing the relevant information elements of the domain. In this part, you will be asked to indicate which operations are utilized by selecting an example which most closely resembles activities in your domain. After selecting the proper example, please indicate your selection by providing a rating of the frequency of occurrence and criticality of the element to satisfactory performance in the domain in the space beside the appropriate example. If two (or all) examples of a specific domain element occur in your domain, please rate only the example with the highest number. For example, if all three examples applied, only example number three (3) would be rated; if examples one (1) and two (2) applied, only two would be rated. If none of the examples are appropriate to your domain, leave the question blank. Indicate your rating for each element using the scale shown below:

FREQUENCY (F)

```
          1          2          3          4          5
          |----------|----------|----------|----------|
   HIGHLY INFREQUENT         AVERAGE         HIGHLY FREQUENT
```

CRITICALITY (C)

```
          1          2          3          4          5
          |----------|----------|----------|----------|
 HIGHLY NON-CRITICAL         AVERAGE         HIGHLY CRITICAL
```

SECTION 1. COGNITION. This operation involves the discovery, comprehension, awareness, or recognition of information elements. In its broadest sense, understanding. More specifically, the process of structuring items of information. Comprehending the blob of color is a garbage truck, understanding the meaning of words organized as a poem, adding a column of numbers, and interpreting the body language of an angry customer are all examples of cognition.

YES____ (answer remaining questions) NO____ (proceed to next section)

F - C

A. COGNITION OF VISUAL UNITS:

___ - ___ 1. Recognizing a simple, distinct, visual form. Seeing four connected lines as a square, identifying a color as "red."

___ - ___ 2. Recognizing a moderately complex visual form along gross dimensions. Identifying an object as a building or recognizing a car versus a jeep or a tank.

___ - ___ 3. Recognizing a complex visual form in varying degrees of background clutter. Resolving an infra-red sensor image as an enemy tank among other heat generating sources or finding a particular face in a crowd.

F - C

B. COGNITION OF VISUAL CLASSES:

___ - ___ 1. Classifying visual items by a few simple or readily apparent attributes. Given a set of objects, which items are blue, which items have wheels, which are biplanes.

___ - ___ 2. Classifying visual forms on several moderately ambiguous or not readily apparent dimensions. Classifying an item as an oak, sycamore, or elm leaf or classifying a building as classic, modern, or futurist architecture.

___ - ___ 3. Classifying complex visual forms on ambiguous or esoteric factors. Defining a painting as a late impressionist period piece or classifying a radar blip as a fighter plane or a passenger transport.

F - C

C. COGNITION OF VISUAL RELATIONS:

___ - ___ 1. Comprehending simple relationships among a few distinct visual forms. Understanding apples and stop signs are "red" or that a book is "on" a table.

___ - ___ 2. Comprehending more involved relationships among a few visual forms. Producing a polygon to complete a sequence such as specifying "hexagon" to complete the sequence of triangle, square, pentagon, or a book may still be "on" the table, even though it has been placed "behind" a box also on the table.

___ - ___ 3. Comprehending complex relationships among potentially ambiguous visual forms and dimensions. Understanding how a Porsche and a Corvette are related or the visual relation of an F-16 and F-15 aircraft.

F - C

D. COGNITION OF VISUAL SYSTEMS:

___ - ___ 1. Perceiving the static arrangement and position a few simple visual forms. The positions of appliances in a kitchen or the position of an object in a two-dimensional plane.

___ - ___ 2. Perceiving the arrangement and spatial position of several moderately complex objects that can move predictably. Identifying a football formation based on the positions of the players or perceiving the position of a single aircraft given its flight plan.

___ - ___ 3. Perceiving the arrangement and spatial positions of members of a complex system of visual forms in varying degrees of background clutter. Understanding the positions of all aircraft in a holding pattern over a busy airport or using terrain feature information to guide a missile to its target.

F - C

E. COGNITION OF VISUAL TRANSFORMATIONS:

___ - ___ 1. Understanding the impact of changes on a simple visual object after some specific, significant changes occur. Recognizing a block has rotated 270 degrees or removing a side from a square to form a triangle.

___ - ___ 2. Understanding the result after several changes are imposed on a moderately complex visual scene. Selecting the correct piece to complete a puzzle or indicating the arrangement of appliances in a kitchen has been changed.

___ - ___ 3. Understanding the impact of subtle changes in a complex visual form. Recognizing a man's face after aging 30 years or perceiving how design changes will affect the visual appearance of a vehicle.

F - C

F. COGNITION OF VISUAL IMPLICATIONS:

___ - ___ 1. Recognizing the obvious consequences inherent in an unambiguous visual scene. Planning a simple circuit diagram or navigating a simple maze.

___ - ___ 2. Recognizing the consequences inherent in a possibly ambiguous visual scene. Planning a route to get from Boston to Long Island or determining if a piece of lumber meets minimum standards for grain and knots.

___ - ___ 3. Understanding the possible consequences in an ambiguous visual scene. Planning an airborne-intercept route based on the opponent's maneuvers or docking a spacecraft with another moving craft.

F - C

G. COGNITION OF AUDITORY UNITS:

___ - ___ 1. Recognizing a simple, distinct, auditory stimulus. Hearing a school bell or recognizing a car horn.

___ - ___ 2. Recognizing a moderately complex auditory stimulus along gross dimensions. Identifying a specific tone from several candidate tones or recognizing examples of rock music.

___ - ___ 3. Recognizing a complex auditory stimulus in varying degrees of background clutter. Picking-out a specific word in a string of speech or identifying an out-of-tune violin in an orchestra.

F - C

H. COGNITION OF AUDITORY CLASSES:

___ - ___ 1. Classifying auditory stimuli by a few simple or readily apparent attributes, such as tones less than 5,000 Hz or sounds between 10 and 10,000 decibels.

___ - ___ 2. Classifying auditory stimuli on several moderately ambiguous or not readily apparent dimensions. Classifying a dog's bark as loud or soft or identifying a car horn as either high or low-pitched.

___ - ___ 3. Classifying complex auditory stimuli on ambiguous or esoteric factors. Describing a musical piece as being composed by Chopin or classifying a submarine from the sound of its screws under water.

F - C

I. COGNITION OF AUDITORY RELATIONS:

___ - ___ 1. Comprehending simple relationships among a few distinct auditory stimuli. Understanding that "middle C" is lower than "high C" or that one tone is in the same key as a given tone.

___ - ___ 2. Comprehending more involved relationships among a few auditory stimuli. Understanding the relationships among notes in a chromatic scale.

___ - ___ 3. Comprehending complex relationships among potentially ambiguous auditory stimuli and dimensions. Understanding how a waltz and a march are related or the similarity of men's voices.

F - C

J. COGNITION OF AUDITORY SYSTEMS:

___ - ___ 1. Perceiving the integration of a few simple sounds to form a unique whole. Understanding a bugler's signal to charge or a simple drum cadence.

___ - ___ 2. Perceiving the integration of several moderately complex sounds. Identifying some of the principle sounds in a busy bus station or interpreting an expected message on the telephone.

___ - ___ 3. Perceiving the arrangement and position of various stimuli in a complex auditory system with varying degrees of background clutter. Understanding a radio communication that is partially jammed or identifying the position of a submarine from several auditory inputs.

F - C

K. COGNITION OF AUDITORY TRANSFORMATIONS:

___ - ___ 1. Understanding the impact of changes on a simple auditory stimulus after some specific changes occur. Recognizing a tone has increased in pitch or that a previously steady tone is now wavering.

___ - ___ 2. Understanding the result of several changes imposed on a moderately complex auditory arrangement. Determining the impact of changing the key of a musical selection or the effect of increasing the tempo of spoken words on intelligibility.

___ - ___ 3. Understanding the impact of subtle changes in a complex auditory system. Recognizing verbal commands made by a pilot under high-g stress or interpreting words that are sung rather than spoken.

F - C

L. COGNITION OF AUDITORY IMPLICATIONS:

___ - ___ 1. Recognizing the obvious consequences inherent in an unambiguous auditory stimulus. Fastening a safety belt when the car "seat-belt buzzer" sounds or that a ringing alarm clock signals time to get-up.

___ - ___ 2. Recognizing the inherent consequences in a possibly ambiguous auditory stimulus. Knowing what to do when the words "Look out!" are heard while walking through a hard-hat area or hearing a wheezing asthma patient and understanding that an attack may be imminent.

___ - ___ 3. Understanding the possible consequences in an ambiguous auditory system. Understanding what is making a baby cry or whether or not a given musical piece is "good."

F - C

M. COGNITION OF SYMBOLIC UNITS:

___ - ___ 1. Recognizing a simple, distinct, symbol. Recognizing a plus (+) sign or an ASCII character.

___ - ___ 2. Recognizing a moderately complex symbol along gross dimensions. Identifying a symbol as a tank or recognizing a company logo.

___ - ___ 3. Recognizing a complex symbol in varying degrees of background clutter. Resolving handwritten words or identifying a specific Chinese pictograph.

F - C

N. COGNITION OF SYMBOLIC CLASSES:

___ - ___ 1. Classifying symbols by a few simple or readily apparent attributes. Grouping mathematical symbols or Arabic numerals.

___ - ___ 2. Classifying symbols on several moderately ambiguous or not readily apparent dimensions. Recognizing military rank insignia or correctly spelled words.

___ - ___ 3. Classifying complex symbols on ambiguous or esoteric factors. Identifying patriotic symbols or specifying symbols of cultural significance.

F - C

O. COGNITION OF SYMBOLIC RELATIONS:

___ - ___ 1. Comprehending simple relationships among a few distinct symbols. Understanding the relationship of "1" and "0" bits in a binary code.

___ - ___ 2. Comprehending more involved relationships among a few symbols. Understanding that "6" is greater than "5"
or "x" operations are performed before "+" operations.

___ - ___ 3. Comprehending complex relationships among a few symbols. Understanding a silver eagle (symbolizing the rank of colonel) outranks a silver bar (symbolizing a first lieutenant).

F - C

P. COGNITION OF SYMBOLIC SYSTEMS:

___ - ___ 1. Perceiving three or more simple symbols composing a collective whole. Examples include telephone or Social Security numbers or letters forming words.

___ - ___ 2. Perceiving the integration of many moderately complex symbols. Understanding a code or symbols used in a military information distribution system.

___ - ___ 3. Perceiving the integration of many complex symbols in different formats. Understanding words organized in sentences or paragraphs.

F - C

Q. COGNITION OF SYMBOLIC TRANSFORMATIONS:

___ - ___ 1. Understanding the impact of changes on simple symbols after some specific changes occur. Updating symbols on a map display as information of their disposition is obtained or translating items from hexadecimal to binary code.

___ - ___ 2. Understanding the impact of several changes imposed on a moderately complex symbol set. Rearranging scrambled letters to form a meaningful word or the impact of note position in the bass clef versus the treble clef.

___ - ___ 3. Understanding the impact of subtle changes in a complex symbol set. Converting written words into their audible counterparts while reading aloud or translating from Russian to English.

F - C

R. COGNITION OF SYMBOLIC IMPLICATIONS:

___ - ___ 1. Recognizing the obvious information inherent in an unambiguous symbol. A green light on a traffic light implies "go" or "=" implies two quantities are equal.

___ - ___ 2. Recognizing the information contained in a possibly ambiguous symbol. The implication of including the first three numbers of a telephone number (i.e., (111) 555- 2345) is that the number is long distance, omitting the prefix implies a local call.

___ - ___ 3. Recognizing the potential information contained in an ambiguous symbol. Understanding a piece of evidence found at a crime site may suggest useful leads for solving the crime, even though its relevance is unknown at this time.

F - C

S. COGNITION OF SEMANTIC UNITS:

___ - ___ 1. Recognizing a simple idea or concept. The sound of a particular note or the meaning of non-complex domain elements such as "dog," "car," "bed," etc.

___ - ___ 2. Recognizing a moderately complex idea or concept. Understanding the meaning of less-general terms in the domain such as "too hot," "sell-short," or other potentially ambiguous concepts or jargon.

___ - ___ 3. Recognizing a complex idea or concept. Understanding meanings of abstract terms like "love," "beautiful," or other highly subjective concepts.

F - C

T. COGNITION OF SEMANTIC CLASSES:

___ - ___ 1. Classifying similar concepts by a few simple or readily apparent attributes. Alphabetizing a list of words or identifying a given formula as a kinematic equation of motion.

___ - ___ 2. Classifying concepts on several moderately ambiguous or not readily apparent dimensions. Classifying styles of architectural design concepts or a particular action belonging to a specific type of military maneuver.

___ - ___ 3. Classifying complex concepts on ambiguous or esoteric factors. Given a specific example, classify a behavior as ethical or non-ethical.

F - C

U. COGNITION OF SEMANTIC RELATIONS:

___ - ___ 1. Comprehending simple, concrete relationships among a few concepts or situations. Understanding the link between "off" and "on."

___ - ___ 2. Comprehending less certain relationships among a few concepts. Understanding the general positive correlation of height and weight or the general inverse relationship of bond prices and interest rates.

___ - ___ 3. Comprehending complex relationships among potentially ambiguous concepts or ideas. Understanding the relationship of the concept of "patriot" to the concept of "nationalism."

F - C

V. COGNITION OF SEMANTIC SYSTEMS:

___ - ___ 1. Perceiving the integration of three or more simple, unambiguous concepts which comprise a unique whole. Understanding the rules of tennis or basic mathematics.

___ - ___ 2. Perceiving the integration of several moderately complex concepts in potentially ambiguous contexts. Identifying key themes in a newspaper article.

___ - ___ 3. Perceiving the integration of many complex concepts in generally ambiguous contexts. Understanding the central themes of "Mein Kampf" or comprehending the meaning of a clergyman's sermon.

F - C

W. COGNITION OF SEMANTIC TRANSFORMATIONS:

___ - ___ 1. Understanding the impact of a few specific changes imposed on a simple conceptual system. Adding water to a glass changes its meaning from "empty" to "full."

___ - ___ 2. Understanding the impact of several changes imposed on a moderately complex conceptual system. Revising a report for a different audience than originally intended.

___ - ___ 3. Understanding the impact of subtle or major changes in a complex conceptual system or situation. Understanding the design changes needed to implement new system requirements or reinterpretation of a court decision based upon new evidence.

F - C

X. COGNITION OF SEMANTIC IMPLICATIONS:

___ - ___ 1. Recognizing the obvious consequences inherent in a unambiguous concept or situation. Seeing a simple circuit diagram or navigating a simple maze.

___ - ___ 2. Recognizing the consequences inherent in a possibly ambiguous visual scene. Planning a route to get from Boston to Long Island or determining if a piece of lumber meets minimum standards for grain and knots.

___ - ___ 3. Understanding the possible consequences in an ambiguous visual scene. Planning an airborne-intercept route based on the opponent's maneuvers or docking a spacecraft with another moving craft.

F - C

Y. COGNITION OF BEHAVIORAL UNITS:

___ - ___ 1. Recognizing a simple, distinct, behavioral action. Perceiving a punch in the face or a salute.

___ - ___ 2. Recognizing a potentially ambiguous behavioral action. Identifying a smile, a wink, or a nod.

___ - ___ 3. Recognizing a complex behavioral action in varying degrees of ambiguity. Identifying a leer, a frown, or a "menacing look."

F - C

Z. COGNITION OF BEHAVIORAL CLASSES:

___ - ___ 1. Classifying behavioral items by a few simple or readily apparent attributes. Given a defined set of simple actions, which are gestures or which are postures.

___ - ___ 2. Classifying a potentially ambiguous behavioral action. Given a set of actions, which indicate hostility or which indicate happiness.

___ - ___ 3. Classifying complex behavioral activities on several potentially ambiguous or not readily apparent dimensions. Classifying a dance as joyful or atmosphere at a meeting as tense.

F - C

AA. COGNITION OF BEHAVIORAL RELATIONS:

___ - ___ 1. Comprehending simple relationships among a few distinct behavioral actions or situations. Waving when one says good-bye or that smiling people are generally happy.

___ - ___ 2. Comprehending relationships between potentially ambiguous behavioral actions or situations. Understanding scared people tend to have higher heart-rates and blood pressures or that dessert usually follows dinner (in many Western cultures).

___ - ___ 3. Comprehending complex relationships among potentially ambiguous behavioral actions or situations. Understanding how to act towards "the boss" at an office party.

F - C

BB. COGNITION OF BEHAVIORAL SYSTEMS:

___ - ___ 1. Perceiving the interactions and acceptable behavior in a simple social system. Understanding basic standards of sportsmanship and fair play during a game of checkers.

___ - ___ 2. Perceiving the interactions and acceptable behavior in a moderately complex social system. Proper etiquette at a formal dinner or acceptable conduct on the basketball court by a player for a given situation.

___ - ___ 3. Perceiving the interactions and acceptable behavior in a complex social system with varying degrees of ambiguity. Understanding what is actually being communicated ("reading between the lines") during a negotiation.

F - C

CC. COGNITION OF BEHAVIORAL TRANSFORMATIONS:

___ - ___ 1. Reinterpreting a simple action or situation, based on new information, to alter its behavioral value. Determining how a particular action (i.e., saying goodbye) might differ between a mother and son or a father and son.

___ - ___ 2. Reinterpreting a possibly ambiguous action or situation, based on new information, to alter its behavioral value. Based on the size ($1, $20, etc.) of the bill found, a person will decide whether or not to turn-in cash found in a business place.

___ - ___ 3. Reinterpreting a complex activity or situation, based on new information, to alter its behavioral value. Despite close military and economic ties, two allies sever relations because of new ideological differences.

F - C

DD. COGNITION OF BEHAVIORAL IMPLICATIONS:

___ - ___ 1. Recognizing the obvious consequences suggested by a simple behavioral action or situation. If the phone rings you answer it or when you wish to enter a room you knock if the door is closed.

___ - ___ 2. Recognizing the possible consequences suggested in a behavioral action. A smile may signify happiness or kicking dirt on an umpire's shoes usually results in ejection from the game.

F - C

___ - ___ 3. Understanding the possible consequences in an ambiguous behavioral activity or situation. Determining if a seller will accept a particular bid or if the body language of a person in a bank carrying a large bag suggests a criminal intent.

SECTION 2. MEMORY. The commitment of cognized information to storage for later use. The information is stored in the same form as cognized and is accessible through the same cues connected to it when stored. Learning is encompassed in this operation. Memorizing a telephone number, an acquaintance's face, or the words to the "Star Spangled Banner," are all examples of the memory operation.

YES____ (answer remaining questions) NO____ (proceed to next section)

F - C

A. MEMORY OF VISUAL UNITS:

___ - ___ 1. Storing a simple, distinct, visual form. Saving a square or a color.

___ - ___ 2. Storing a moderately complex visual form along gross dimensions. Saving an object called "bank" or and object called "jeep."

___ - ___ 3. Storing a complex visual form in varying degrees of background clutter. Saving the image of a enemy fighter's radar signature or the nuclear-magnetic resonance image of a fractured femur.

F - C

B. MEMORY OF VISUAL CLASSES:

___ - ___ 1. Storing visual items categorized by a few simple or readily apparent attributes. Saving objects in classes such as blue items or wheeled items, etc.

___ - ___ 2. Storing visual forms categorized on several moderately ambiguous or not readily apparent dimensions. Saving objects as leaves, vintage automobiles, etc.

___ - ___ 3. Storing complex visual forms categorized on ambiguous or esoteric factors. Saving images of paintings as examples of cubism, efficient house plans, or ugly colors.

F - C

C. MEMORY OF VISUAL RELATIONS:

___ - ___ 1. Saving simple relationships among a few distinct visual forms. Recording that a stop sign, apple, and cherry are examples of the color red.

___ - ___ 2. Saving more involved relationships among a few visual forms. Recording that a one object is "closer" than another or an object is "to the right" of another object.

___ - ___ 3. Saving complex relationships among potentially ambiguous visual forms and dimensions. Recording that a Porsche and a Corvette are related since they look like "sports cars" or that some symptoms (such as a skin rash) may look the same for different illnesses.

F - C

D. MEMORY OF VISUAL SYSTEMS:

___ - ___ 1. Recording the static arrangement and position a few simple visual forms. Storing positions of appliances in a kitchen or the position of an object in a two-dimensional plane.

___ - ___ 2. Recording the arrangement and spatial position of several moderately complex objects. Recalling play tendency based upon a given football formation or the position of all aircraft in a holding pattern.

___ - ___ 3. Recording the arrangement and spatial positions of members of a complex system of visual form in varying degrees of background clutter. Recalling the arrangement and positions of organs in the abdomen.

F - C

E. MEMORY OF VISUAL TRANSFORMATIONS:

___ - ___ 1. Saving result simple, significant changes on a simple visual object. Storing the image of a block after rotating it 180 degrees or designating an object as now red in color instead of blue.

___ - ___ 2. Understanding the result after several changes are imposed on a moderately complex visual scene. Selecting the correct piece to complete a puzzle or the arrangement of appliances in a kitchen has been changed.

___ - ___ 3. Understanding the impact of subtle changes in a complex visual form. Storing a man's face after aging 30 years or recording how design changes will affect the visual appearance of a vehicle.

F - C

F. MEMORY OF VISUAL IMPLICATIONS:

___ - ___ 1. Storing the obvious consequences inherent in an unambiguous visual scene. Recalling a simple circuit diagram or directions to a particular place.

___ - ___ 2. Storing the learned consequences inherent in a possibly ambiguous visual scene. Recalling alternate routes to get from the airport to your house or recalling the standards for determining if a piece of fruit is Grade "A," "B," or discarded.

___ - ___ 3. Storing the possible learned consequences in an ambiguous visual scene. Recalling which air-to-air maneuvers are most effective for a given aerial combat situation or what ailments are suggested by red, mottled skin.

F - C

G. MEMORY OF AUDITORY UNITS:

___ - ___ 1. Storing a simple, distinct, auditory stimulus. Recalling the sound of a school bell or a car horn.

___ - ___ 2. Storing a moderately complex auditory stimulus along gross dimensions. Recalling a specific tone from several candidate tones or recalling examples of rock music.

___ - ___ 3. Storing a complex auditory stimulus in varying degrees of background clutter. Recalling the way individual words sound.

F - C

H. MEMORY OF AUDITORY CLASSES:

___ - ___ 1. Storing classifications of auditory stimuli on a few simple or readily apparent attributes. Storing all tones less than 5,000 Hz or sounds between 10 and 10,000 decibels.

___ - ___ 2. Storing classifications of auditory stimuli on several moderately ambiguous or not readily apparent dimensions. Storing a dog's bark as loud or soft or a car horn as either high or low-pitched.

___ - ___ 3. Storing classifications of complex auditory stimuli on ambiguous or esoteric factors. Storing examples of music composed by Chopin or submarine classifications based on the acoustic signature of its screws under water.

F - C

I. MEMORY OF AUDITORY RELATIONS:

___ - ___ 1. Saving simple relationships among a few distinct auditory stimuli. Storing the relative frequency difference of two tones.

___ - ___ 2. Saving more involved relationships among a few auditory stimuli. Storing the relationships between frequency spectrums and harmonics of several sounds.

___ - ___ 3. Saving complex relationships among potentially ambiguous auditory stimuli and dimensions. Storing a variety of relationships among several sounds such as sound quality, tonal characteristics, or "pleasantness."

F - C

J. MEMORY OF AUDITORY SYSTEMS:

___ - ___ 1. Recording the arrangement and position of a few simple sounds that form a unique whole. Remembering the position of a ticking clock on the nightstand beside your bed or knowing the position of a passing motorist from hearing her vehicle.

___ - ___ 2. Recording the arrangement and position of several moderately complex sounds. Remembering where certain pieces of heavy equipment are located based on the relative loudness of each machine.

___ - ___ 3. Recording the arrangement and position of various stimuli in a complex auditory system with varying degrees of background clutter. Remembering the position of voices of various people seated around you at an event.

F - C

K. MEMORY OF AUDITORY TRANSFORMATIONS:

___ - ___ 1. Saving the impact of changes on a simple auditory stimulus after some specific changes occur. Recalling how a squeaky door sounds after oiling it.

___ - ___ 2. Saving the result of several changes imposed on a moderately complex auditory arrangement. Storing the impact of changing the tempo and key signature on a piece of music.

___ - ___ 3. Saving the impact of subtle changes in a complex auditory system. Storing verbal commands made by a pilot under high-g stress or interpreting words that are sung rather than spoken.

F - C

L. MEMORY OF AUDITORY IMPLICATIONS:

___ - ___ 1. Storing the obvious consequences inherent in an unambiguous auditory stimulus. Recalling to fasten a safety belt when the car "seat-belt buzzer" sounds or remembering that a ringing alarm clock signals time to get-up.

___ - ___ 2. Storing the learned consequences in a possibly ambiguous auditory system. Remembering how an asthma patient sounds just before having an asthma attack or how a properly tuned engine sounds.

___ - ___ 3. Storing the learned consequences in an ambiguous auditory system. Recalling what to do to relieve a particular sound of a baby's crying (i.e., a "hungry" cry or "change me" cry).

F - C

M. MEMORY OF SYMBOLIC UNITS:

___ - ___ 1. Storing a simple, distinct, symbol. Storing a plus (+) sign or an ASCII character.

___ - ___ 2. Storing a moderately complex symbol. Recalling an oil symbol in an auto or remembering the company associated with a particular logo.

___ - ___ 3. Storing a complex symbol for recognition in varying degrees of background clutter. Recalling handwritten words or a specific Chinese pictograph.

F - C

N. MEMORY OF SYMBOLIC CLASSES:

___ - ___ 1. Storing symbolic classifications by a few simple or readily apparent attributes. Saving groupings of correctly spelled words or Arabic numerals.

___ - ___ 2. Storing symbolic classifications on several moderately ambiguous or not readily apparent dimensions. Storing military rank insignia or national flags.

___ - ___ 3. Storing complex symbols classified on ambiguous or esoteric factors. Recalling patriotic symbols or symbols of cultural significance.

F - C

O. MEMORY OF SYMBOLIC RELATIONS:

___ - ___ 1. Saving simple relationships among a few distinct symbols. Recalling that "26" is greater than "15" or "+" operations are performed before "x" operations.

___ - ___ 2. Saving more involved relationships among a few symbols. Remembering a silver star (symbolizing the rank of general) outranks a two silver bars (symbolizing the rank of captain).

___ - ___ 3. Saving complex relationships among several symbols. Recalling which elements of the periodic table can be combined (within the laws of physics).

F - C

P. MEMORY OF SYMBOLIC SYSTEMS:

___ - ___ 1. Recording three or more simple symbols composing a collective whole. Saving telephone or Social Security numbers or letters forming words.

___ - ___ 2. Recording the integration of many moderately complex symbols. Storing words organized in simple sentences or symbols used in a military information distribution system.

___ - ___ 3. Recording the integration of many complex symbols. Saving a highly-complex military code or storing genetic code information.

F - C

Q. MEMORY OF SYMBOLIC TRANSFORMATIONS:

___ - ___ 1. Recording the impact of changes on simple symbols after some specific changes occur. Updating symbols on a map display as information of their disposition is obtained or recalling translations of individual words from the Japanese to English language.

___ - ___ 2. Recording the impact of several changes imposed on a moderately complex symbol set. Recalling typical letter sequences to arrange scrambled letters to form a meaningful word or the remembering the notes for a given position in the bass clef versus the treble clef.

___ - ___ 3. Recording the impact of subtle changes in a complex symbol set. Recalling the audible counterparts of written words for reading aloud or translating from Russian to English.

F - C

R. MEMORY OF SYMBOLIC IMPLICATIONS:

___ - ___ 1. Storing the obvious information inherent in an unambiguous symbol. Recalling a red light on a traffic light implies "stop" or "-" implies subtraction of two quantities.

___ - ___ 2. Storing the information contained in a possibly ambiguous symbol. Recording the implication that inclusion of the first three numbers of a telephone number (i.e., (111) 555-2345) means the number is a long distance call.

___ - ___ 3. Storing information contained in an ambiguous symbol. Recording the salient aspects of an unknown symbol for later evaluation (i.e., "I'm not sure what this means, but I'll remember it in case I see it in the future).

F - C

S. MEMORY OF SEMANTIC UNITS:

___ - ___ 1. Storing the meaning of a simple idea or concept. Saving the sound of a particular note or the meaning of basic domain elements such as "dog," "car," "bed," etc.

___ - ___ 2. Storing the meaning of a moderately complex idea or concept. Recalling the meaning of less-general terms in the domain such as "too hot," "sell-short," or other potentially ambiguous concepts or jargon.

___ - ___ 3. Storing the meaning or interpretation of a complex idea or concept. Remembering meanings of abstract terms like "love," "beautiful," or other highly subjective concepts.

F - C

T. MEMORY OF SEMANTIC CLASSES:

___ - ___ 1. Encoding similar concepts classified on a few simple or readily apparent attributes. Saving groups of words that have like meanings or objects that share an obvious, common purpose.

___ - ___ 2. Encoding concepts classified on several moderately ambiguous or not readily apparent dimensions. Storing similar types of architectural design concepts or a grouping football plays for particular down and distance situations (i.e., First and 10 plays are different than Third and Long plays).

___ - ___ 3. Encoding complex concepts classified on ambiguous or esoteric factors. Saving various types of speeches for the President based on the type of public opinion they are intended to evoke (i.e., some speeches used for patriotic occasions, others for national crisis, etc.).

F - C

U. MEMORY OF SEMANTIC RELATIONS:

___ - ___ 1. Saving simple, concrete relationships among a few concepts or situations. Storing the link between "start" and "finish" or other simple antonyms or synonyms.

___ - ___ 2. Saving less certain relationships among a few concepts. Recalling the general positive correlation of personal income and standard of living or the general relationship of the of "husband" to "wife."

___ - ___ 3. Saving complex relationships among potentially ambiguous concepts or ideas. Storing knowledge of the concept of "communism" relative to the concept of "socialism."

F - C

V. MEMORY OF SEMANTIC SYSTEMS:

___ - ___ 1. Recording the integration of three or more simple, unambiguous concepts which comprise a unique whole. Storing the rules of chess or basic accounting.

___ - ___ 2. Recording the integration of several moderately complex concepts in potentially ambiguous contexts. Recalling key meanings in an interoffice memo.

___ - ___ 3. Recording the integration of many complex concepts in generally ambiguous contexts. Remembering the central themes of "Das Kapital" or the meaning of a teacher's lecture.

F - C

W. MEMORY OF SEMANTIC TRANSFORMATIONS:

___ - ___ 1. Recalling the impact of simple changes imposed on basic concepts. Saving the redefinition of a new use for a simple item (i.e., a child remembering a phone book can be useful as a step-stool).

___ - ___ 2. Recalling the impact of several changes imposed on a moderately complex conceptual system. Saving the revision that an aircraft is experiencing mechanical problems and will be unable to depart as scheduled.

___ - ___ 3. Understanding the impact of subtle or major changes in the interpretation of a complex conceptual system or situation. Saving the changes needed to make an old social welfare program responsive to the new needs of welfare recipients.

F - C

X. MEMORY OF SEMANTIC IMPLICATIONS:

___ - ___ 1. Storing the obvious consequences inherent in a unambiguous concept or situation. Recalling the consequences associated with the word "hot" or "danger."

___ - ___ 2. Storing the learned consequences inherent in a possibly ambiguous conceptual system. Recalling the tools used in performing a given job or the procedures required to alert the maintenance crew an aircraft requires their attention.

___ - ___ 3. Storing the learned possible consequences suggested in an ambiguous conceptual system or situation. Recalling the necessary steps taken (and other steps considered) in past (but slightly different) situations to alleviate a patient's suffering.

F - C

Y. MEMORY OF BEHAVIORAL UNITS:

___ - ___ 1. Storing a simple, distinct, behavioral action. Recording a smile, a wink, a salute, or crying.

___ - ___ 2. Storing a moderately complex behavioral action with possible ambiguity. Recalling a "come here" gesture or storing the different ways a mother can say "no."

___ - ___ 3. Storing a complex behavioral action with some degree of ambiguity. Recalling how an "icy gaze" or a "sheepish grin" appears.

F - C

Z. MEMORY OF BEHAVIORAL CLASSES:

___ - ___ 1. Encoding behavioral items classified on a few simple or readily apparent attributes. Storing actions which indicate a number or specify a direction.

___ - ___ 2. Encoding moderately complex behavioral activities classified on potentially ambiguous dimensions. Storing actions which suggest happiness or illness.

___ - ___ 3. Encoding complex behavioral activities classified on several potentially ambiguous or not readily apparent dimensions. Storing ballets grouped according to their moods (i.e., somber or joyous) or recalling feelings associated with people based upon their personality.

F - C

AA. MEMORY OF BEHAVIORAL RELATIONS:

___ - ___ 1. Saving simple relationships among a few distinct behavioral actions or situations. Remembering when it is appropriate to salute or to stand when the national anthem is played.

___ - ___ 2. Saving moderately complex relationships among potentially ambiguous behavioral actions.

___ - ___ 3. Saving complex relationships among ambiguous behavioral actions or situations. Remembering political or ideological beliefs of certain individuals and how to relate to them to minimize conflict.

F - C

BB. MEMORY OF BEHAVIORAL SYSTEMS:

___ - ___ 1. Recording the acceptable interactions and activities in a simple social system. Recalling the proper way to behave when playing with other children (no hitting, no biting, sharing toys, etc.).

___ - ___ 2. Recording the interactions and acceptable actions in a moderately complex social system. Recalling the proper fork to use at a formal dinner.

___ - ___ 3. Recording the interactions and acceptable actions in a complex social system with varying degrees of ambiguity. Saving environmental cues (i.e., the behaviors of others) that suggest acceptable norms and behaviors in a foreign setting.

F - C

CC. MEMORY OF BEHAVIORAL TRANSFORMATIONS:

___ - ___ 1. Recording the reinterpretation of a simple action that alters its behavioral value. After a child is spanked for writing on the livingroom wall, she now interprets the act of writing on the wall as unacceptable behavior.

___ - ___ 2. Recording the reinterpretation of a moderately complex behavioral action or situation. An automobile driver who habitually exceeds the speed limit sees graphic portrayals of accidents due to excessive speed and then updates her belief system to view speeding as inappropriate.

___ - ___ 3. Recording the reinterpretation of a complex behavioral activity that alters its behavioral value. Updating the previously negative cultural stereotypes held by an individual about certain ethnic groups after positively interacting with members of these groups.

F - C

DD. MEMORY OF BEHAVIORAL IMPLICATIONS:

___ - ___ 1. Storing the learned consequences explicit in a non-complex behavioral situation or action. Recalling that specific actions (such as crying) result in specific outcomes (comforting from a parent).

F - C

___ - ___ 2. Storing the learned consequences suggested in a generally unambiguous behavioral action or situation. Recalling a smile may signify happiness or amusement or striking someone often results in retaliation.

___ - ___ 3. Storing the learned consequences in an ambiguous behavioral activity or situation. Remembering which sales pitches result in the greatest success based upon the probable background of the buyer or how to calm an unruly crowd at a rock concert.

SECTION 3. DIVERGENT PRODUCTION. This operation involves the generation of alternative information elements from the memory store, in either exact or modified form, where the emphasis is placed upon variety, quantity, and relevance of the alternatives to satisfy the conditions of a particular situation. Also called inductive reasoning. Naming objects that are both heavy and mobile and brainstorming alternative solutions to a problem are examples of divergent production. Engaging in creative activity of any kind relies heavily on the mental operation of divergent production.

YES____ (answer remaining questions) NO____ (proceed to next section)

F - C

A. DIVERGENT PRODUCTION OF VISUAL UNITS:

___ - ___ 1. Generating simple, distinct, visual forms to satisfy a simple requirement. Producing a triangle, square and circle for the requirement of "basic shapes."

___ - ___ 2. Generating a moderately complex visual form given some possibly ambiguous dimension(s). Producing several undetailed images of shops, passers-by, and autos for the requirement of "things seen on a street."

___ - ___ 3. Generating a complex visual form to satisfy potentially ambiguous requirement(s). Producing a number of highly- detailed images to satisfy the requirement of "landscapes in the impressionistic style of Monet."

F - C

B. DIVERGENT PRODUCTION OF VISUAL CLASSES:

___ - ___ 1. Generating alternative ways of classifying simple visual items by readily apparent attributes. Classifying a group of shapes by size, number of sides, or color.

___ - ___ 2. Generating alternative ways of classifying moderately complex visual forms on moderately ambiguous or not readily apparent dimensions. Classifying a group of buildings by age or "usable" square-footage.

___ - ___ 3. Generating alternative ways of classifying complex visual forms by ambiguous or esoteric attributes. Classifying cities by "quality of life," "attractiveness," or "desirability."

F - C

C. DIVERGENT PRODUCTION OF VISUAL RELATIONS:

___ - ___ 1. Producing a variety of simple relationships among a few distinct visual forms. Listing a number of relationships between a pair of apples, such as apple 1 is redder and bigger than apple 2, while apple 2 is rounder and glossier than apple 1.

___ - ___ 2. Producing a variety of moderately complex relationships among a few visual forms. Specifying a certain auto looks "boxy" compared to another.

___ - ___ 3. Producing complex relationships among potentially ambiguous visual forms and dimensions. Describing one picture as being "warmer and more appealing" than another or examining a patient and relating his physical appearance to understandable terms for discussing the condition with a colleague (i.e., "He looked like ...").

F - C

D. DIVERGENT PRODUCTION OF VISUAL SYSTEMS:

___ - ___ 1. Inventing a number of simple composites using a few simple visual forms to satisfy a definite requirement. Given three lines, one arc, and a square, produce as many pictures of real objects as possible.

___ - ___ 2. Inventing a number of moderately complex objects using more complex visual forms to satisfy some requirement. Using several fruit and flower images, design different wallpaper patterns.

___ - ___ 3. Inventing a number of complex objects using complex visual forms to satisfy an ambiguous requirement. Developing alternative versions of a painting or sculpture.

F - C

E. DIVERGENT PRODUCTION OF VISUAL TRANSFORMATIONS:

___ - ___ 1. Creating alternative ways of processing simple visual information to satisfy a distinct requirement. Describing the possible ways of changing a simple scene to change its meaning.

___ - ___ 2. Creating alternative ways of processing moderately complex visual information to satisfy some requirements. Specifying ways of changing a dress pattern to make the dress "more formal."

___ - ___ 3. Creating alternative ways of processing complex visual information to satisfy ambiguous requirements. Changing the packaging of a product to make it more "appealing" to buyers or a pilot inventing alternative routes to efficiently complete a skywritten message.

F - C

F. DIVERGENT PRODUCTION OF VISUAL IMPLICATIONS:

___ - ___ 1. Creating various alternatives suggested by distinct visual information to conform to exact requirements. Producing alternate colors to use for representing a specific state or condition.

___ - ___ 2. Creating various alternatives suggested by possibly ambiguous visual information to satisfy general requirements. Producing alternate cake decorations for a boy's birthday or for a girl's birthday.

___ - ___ 3. Creating various alternatives suggested by ambiguous visual information to satisfy ambiguous requirements. Developing several interior design schemes to blend with the surrounding architecture or designing a space laboratory living quarters to be both functionally efficient and esthetically pleasing.

F - C

G. DIVERGENT PRODUCTION OF AUDITORY UNITS:

___ - ___ 1. Generating a variety of simple, distinct, auditory stimuli for a specific requirement. Specify sounds heard in a school gym or loud noises at an airport.

___ - ___ 2. Generating a number of moderately complex auditory stimuli to satisfy some general requirements. Produce examples of sounds from a violin or examples of animal sounds.

___ - ___ 3. Generating a variety of complex auditory stimuli to satisfy ambiguous requirements. Producing the word "exit" as spoken in different languages.

F - C

H. DIVERGENT PRODUCTION OF AUDITORY CLASSES:

___ - ___ 1. Generating alternative ways of classifying auditory stimuli by a few simple or readily apparent attributes. Grouping sounds by exact frequency ranges or loudness determined in decibels.

___ - ___ 2. Generating alternative ways of classifying auditory stimuli on several moderately ambiguous or not readily apparent dimensions. Given a set of dog barks, specify possible groups such as loud or soft, high or low-pitched, or "mean dogs" or "nice dogs."

___ - ___ 3. Generating alternative ways of classifying complex auditory stimuli on ambiguous or esoteric factors. Hearing a conversation and describing dimensions for classifying it as friendly, hostile, or non-commital.

F - C

I. DIVERGENT PRODUCTION OF AUDITORY RELATIONS:

___ - ___ 1. Producing a number of simple relationships among a few distinct auditory stimuli. Generating basic relationships, such as loudness, key, or pitch among a set of tones.

___ - ___ 2. Producing more involved relationships among a few auditory stimuli. Generating alternative relationships among various "meows" of a pet cat relative to the cat's desire to eat, go out, etc.

___ - ___ 3. Producing complex relationships among potentially ambiguous auditory stimuli and dimensions. Generating relationships between expected sounds of a cardiac patient's heart and the observed sounds.

F - C

J. DIVERGENT PRODUCTION OF AUDITORY SYSTEMS:

___ - ___ 1. Generating a few simple sounds to form several unique systems that meet specific requirements. Combining several tones to produce different warning signals.

___ - ___ 2. Generating several moderately complex auditory systems to satisfy general requirements. Specifying various short musical melodies for use as doorbell tunes.

___ - ___ 3. Generating complex auditory systems to satisfy a number of ambiguous requirements. Composing new theme music for a motion picture.

F - C

K. DIVERGENT PRODUCTION OF AUDITORY TRANSFORMATIONS:

___ - ___ 1. Envisioning the impact of specific changes upon a simple auditory stimulus. Imagining how an a particular alarm might be changed to enhance its audibility or attention- getting qualities.

___ - ___ 2. Envisioning the impact of several changes imposed on a moderately complex auditory system. Imagining the impact of changing the key and tempo of an musical selection to adapt it to a new audience (i.e., adapting pop tunes for "easy listening" formats).

___ - ___ 3. Envisioning the impact of subtle changes in a complex auditory system. Imagining how an automobile engine sound will change based upon changes in the idle speed, carburetor adjustment, or other fine-tuning adjustments.

F - C

L. DIVERGENT PRODUCTION OF AUDITORY IMPLICATIONS:

___ - ___ 1. Generating several alternative consequences perceived to be inherent in a distinct auditory stimulus. Inferring possible meanings of being "honked at" in traffic by a passing motorist (i.e., lights are on, taillights are inoperative, car is on fire, etc.).

___ - ___ 2. Generating various alternative consequences perceived to be inherent in a possibly ambiguous auditory stimulus. Producing several hypotheses about the origin of a "strange sucking sound" heard by a doctor during a routine examination of a patient's lungs.

___ - ___ 3. Generating various alternative consequences perceived to be inherent in an ambiguous auditory system. Imagining the possible origins of "cosmic noise" or if a particular tone of voice is "threatening."

F - C

M. DIVERGENT PRODUCTION OF SYMBOLIC UNITS:

___ - ___ 1. Generating a number of simple, distinct, symbols to meet a specific requirement. Producing as many three letter words ending in "id" as possible.

___ - ___ 2. Generating a number of moderately complex symbols to meet general requirements. Producing several logos to represent a new product.

___ - ___ 3. Generating a number of complex symbols to meet ambiguous or conflicting requirements. Imagining alternative icons for representing human activities (such as the standard international traffic symbols).

F - C

N. DIVERGENT PRODUCTION OF SYMBOLIC CLASSES:

___ - ___ 1. Producing alternative classifications of symbols on obvious dimensions. Suggesting ways of grouping simple symbols such as numbers with curves (i.e., 2,3,5) or no curves (i.e., 1,4).

___ - ___ 2. Producing alternative classifications of symbols on several moderately ambiguous or not readily apparent dimensions. Suggesting new ways of grouping punctuation marks (i.e., select those typically used by accountants, or those with several meanings, etc.).

___ - ___ 3. Producing alternative classifications of complex symbols on ambiguous or esoteric factors. Suggesting new ways of grouping patriotic symbols (i.e., symbols that became popular in WWII but continue to endure, etc.) or symbols of cultural significance (i.e., symbols that people can walk in, etc.).

F - C

O. DIVERGENT PRODUCTION OF SYMBOLIC RELATIONS:

___ - ___ 1. Producing a number of simple relationships among a few distinct symbols to meet specific requirements. Generating various number combinations that must add to a specified sum.

___ - ___ 2. Producing a number of more involved relationships among a few symbols to satisfy general requirements. Generating various operations (within a domain, such as calculus) that could be used to reach a desired result.

___ - ___ 3. Producing a number of complex relationships among a few ambiguous symbols to satisfy ambiguous requirements. Generating various ways the letters JFK, LBJ, and MLK are related.

F - C

P. DIVERGENT PRODUCTION OF SYMBOLIC SYSTEMS:

___ - ___ 1. Generating three or more simple symbols composing a collective whole. Examples include telephone or Social Security numbers or letters forming words.

___ - ___ 2. Generating the integration of many moderately complex symbols to meet general requirements. Words organized in simple sentences or symbols used in a military information distribution system.

___ - ___ 3. Generating a highly complex symbolic system to meet ambiguous requirements. Developing a top secret code for sending highly sensitive military information.

F - C

Q. DIVERGENT PRODUCTION OF SYMBOLIC TRANSFORMATIONS:

___ - ___ 1. Generating a number of possible changes that can be imposed on a simple symbol to satisfy a specific requirement. Producing alternative printer fonts that could be used for printing a business letter.

___ - ___ 2. Generating a number of possible changes that can be imposed on a moderately complex symbol set. Producing possible updates required for symbols on a map display given the status of those symbols or ways of measuring out exactly three cups of water given a five-cup and a two-cup container.

___ - ___ 3. Generating a number of possible changes in a complex symbol set. Producing alternative ways of modifying a code to circumvent attempts to "break" it.

F - C

R. DIVERGENT PRODUCTION OF SYMBOLIC IMPLICATIONS:

___ - ___ 1. Generating alternatives on the nature of information contained in a simple, distinct, symbol. Given two common words, produce a variety of other word pairs using all available letters in the given words.

___ - ___ 2. Generating alternatives on the nature of information contained in possibly ambiguous symbols. Inferring a variety of equations that follow from two given equations composed of letters.

___ - ___ 3. Generating alternatives on the nature of information contained in ambiguous, complex symbols. Given a swastika and the Star of David, produce a variety of words associated with those symbols.

F - C

S. DIVERGENT PRODUCTION OF SEMANTIC UNITS:

___ - ___ 1. Generating many basic ideas for a given simple concept. Name as many items as possible that are red or specify things that fly.

___ - ___ 2. Generating many ideas for a given moderately complex concept. Produce as many ideas as possible that are green and inedible or common uses for a rake.

___ - ___ 3. Generating many ideas for a given a complex concept. Suggesting titles for a short story or producing many examples of things that are warm, cuddly, and friendly.

F - C

T. DIVERGENT PRODUCTION OF SEMANTIC CLASSES:

___ - ___ 1. Producing many classes of ideas suggested by a given, basic concept. Arranging several given words in a variety of meaningful groups.

___ - ___ 2. Producing many classes of ideas suggested by a given moderately complex concept. List alternative uses for a chair, other than its common use.

___ - ___ 3. Producing many classes of ideas suggested by a given complex concept. Describe a variety of uses for a supercomputer or alternative examples for teaching a particular concept.

F - C

U. DIVERGENT PRODUCTION OF SEMANTIC RELATIONS:

___ - ___ 1. Producing many simple, concrete relationships among a few concepts or situations. Produce a number of synonyms for a given word.

___ - ___ 2. Producing many less certain relationships among a few concepts. Specify a number of words to fill a blank in a given simile.

___ - ___ 3. Producing many complex relationships among potentially ambiguous concepts or ideas. Specify ideas related to the concept of religion or topics related to the theory of evolution.

F - C

V. DIVERGENT PRODUCTION OF SEMANTIC SYSTEMS:

___ - ___ 1. Organizing words into a number of meaningful concepts in a given, concrete context. Writing some alternative headlines for a major news story or a short synopsis of a specific event.

___ - ___ 2. Organizing words into a number of meaningful, moderately complex concepts in potentially ambiguous contexts. Given five single letters, composing a number of five-word sentences or completing a simile giving explanatory remarks for the words chosen.

___ - ___ 3. Organizing words into a number of meaningful, complex concepts in generally ambiguous contexts. Writing an article about a new fashion trend or producing a report of a patient's condition.

F - C

W. DIVERGENT PRODUCTION OF SEMANTIC TRANSFORMATIONS:

___ - ___ 1. Producing unconventional (insightful) alternatives based on a reinterpretation or new emphasis on an obvious or logical aspect of an object or situation. Producing a variety of symbols for representing given activities or objects.

___ - ___ 2. Producing unconventional (insightful) alternatives based on a reinterpretation or new emphasis on a moderately ambiguous aspect of an object or a situation. Producing clever or witty titles for a given short story.

___ - ___ 3. Producing unconventional (insightful) alternatives based on a reinterpretation or new emphasis on some aspect of an object or a situation. Solving riddles or specifying remote consequences (based on distance in time, space, or probability) of a given event.

F - C

X. DIVERGENT PRODUCTION OF SEMANTIC IMPLICATIONS:

___ - ___ 1. Generating many possible causes, parallel events, or outcomes suggested by a simple concept. Given a light bulb does not work, specify several possible causes and several possible consequences.

___ - ___ 2. Generating many possible causes, parallel events, or outcomes suggested by a moderately complex concept. Given a tape recorder does not work, specify several possible causes and several possible consequences.

___ - ___ 3. Generating many possible causes, parallel events, or outcomes suggested by a complex concept. Given a heart-lung machine is inoperative, specify several possible causes and several possible consequences.

F - C

Y. DIVERGENT PRODUCTION OF BEHAVIORAL UNITS:

___ - ___ 1. Generating a number of simple, distinct, behavioral alternatives to satisfy a specific situation or condition. Given the situation of a birthday party, supposing that smiling laughing and talking will be appropriate behavior.

___ - ___ 2. Generating a number of complex behavioral alternatives to satisfy a moderately ambiguous situation or condition. Given the situation of a wedding, supposing that making conversation dancing with the bride or groom, and toasting the couple will all be appropriate activities.

___ - ___ 3. Generating a number of complex behavioral alternatives to satisfy an ambiguous situation or condition. Given the situation of being held hostage by terrorists, supposing that lying, stealing, and even killing may be appropriate to insure survival.

F - C

Z. DIVERGENT PRODUCTION OF BEHAVIORAL CLASSES:

___ - ___ 1. Producing various alternative ways of classifying behavioral items by a few simple or readily apparent attributes. Group simple actions (smiling, waving, eating, etc.) in a variety of ways.

___ - ___ 2. Producing alternative ways of classifying moderately complex behavioral activities on several potentially ambiguous or not readily apparent dimensions. Group funerals, birthdays, and anniversaries on a number of meaningful dimensions.

___ - ___ 3. Producing various alternative ways of classifying complex behavioral activities on several potentially ambiguous or not readily apparent dimensions. Group the complex human activities of war, politics, literary pursuit, and exploration in several different ways.

F - C

AA. DIVERGENT PRODUCTION OF BEHAVIORAL RELATIONS:

___ - ___ 1. Producing a number of simple relationships among a few distinct behavioral actions or situations. Specify how a frown, a grimace and smile might be related.

___ - ___ 2. Producing a number of moderately complex relationships among potentially ambiguous behavioral actions or situations. Specify how a judge, a policeman, and a tax collector might be related in terms of their professions.

___ - ___ 3. Producing a number of complex relationships among potentially ambiguous behavioral actions or situations. Specify how any two given members of the European Community are economically and politically related.

F - C

BB. DIVERGENT PRODUCTION OF BEHAVIORAL SYSTEMS:

___ - ___ 1. Generating the alternative interactions and acceptable actions in a simple, well-defined, social system. Given the context of routine military operations, produce appropriate behaviors for an enlisted man encountering an officer.

___ - ___ 2. Generating the alternative interactions and acceptable actions in a moderately complex social system. Given the context of a busy street intersection, produce appropriate behaviors for a young man encountering an elderly woman.

___ - ___ 3. Generating the alternative interactions and acceptable actions in a complex social system with varying degrees of ambiguity. Given the context of chaos following a natural disaster, produce appropriate behaviors for survivors.

F - C

CC. DIVERGENT PRODUCTION OF BEHAVIORAL TRANSFORMATIONS:

___ - ___ 1. Producing unconventional (insightful) alternatives based on a reinterpretation or new emphasis on a well-defined object or situation. A basketball coach generating possible modifications to an existing offense for responding (exploiting) a particular defensive strategy employed by an opposing team.

___ - ___ 2. Producing unconventional (insightful) alternatives based on a reinterpretation or new emphasis on a moderately complex object or situation. A company Chief Executive Officer developing alternative business strategies and policies to insure the company's future competitiveness, based on hazy financial and economic forecasts.

___ - ___ 3. Producing unconventional (insightful) alternatives based on a reinterpretation or new emphasis on a complex object or situation. Choreographing a ballet to portray changing mood conveyed by the music or storyline.

F - C

DD. DIVERGENT PRODUCTION OF BEHAVIORAL IMPLICATIONS:

___ - ___ 1. Generating many possible causes, parallel events, or outcomes suggested by a simple behavioral concept. Given a smiling person, specify several possible causes of the smile and several possible consequences.

___ - ___ 2. Generating many possible causes, parallel events, or outcomes suggested by a moderately complex behavioral concept. Given a person who has just received a speeding ticket, specify several possible behavioral consequences and several ways to ameliorate any negative consequences.

F - C

___ - ___ 3. Generating many possible causes, parallel events, or outcomes suggested by a complex concept. Given a depressed person, specify several possible causes, several possible consequences, and several recommended treatments.

SECTION 4. CONVERGENT PRODUCTION. Retrieving from memory store a specific element of information, which involves the generation of logical conclusions based on given information. Traditionally identified as deductive reasoning. Proceeding to an answer by following rules or algorithms, such as determining a friend's age by subtracting his birthyear from the current year, or determining the question to a Jeopardy! answer.

YES____ (answer remaining questions) NO____ (proceed to next section)

F - C

A. CONVERGENT PRODUCTION OF VISUAL UNITS:

___ - ___ 1. Producing a simple, distinct, visual form to satisfy a specific requirement. Drawing a square when asked or making a simple picture for a specific item.

___ - ___ 2. Producing a moderately complex visual form to satisfy a specific requirement. Drawing a car with four wheels, windshield, and other gross descriptive elements when asked to produce an automobile.

___ - ___ 3. Producing a complex visual form to satisfy a specific requirement. Drawing a highly detailed image of a microwave oven (showing digital readout, knobs, logos, etc.) when asked to produce a modern kitchen appliance designed to cook food quickly.

F - C

B. CONVERGENT PRODUCTION OF VISUAL CLASSES:

___ - ___ 1. Determining the classification of a non-complex visual item by a specified, well-defined, attribute. Sort the letters of the alphabet as either containing curved lines or not or given five polygons select all with four or less sides.

___ - ___ 2. Determining the classification of a moderately complex visual item based on a specified attribute. Given 15 bicycles, classify each them in two groups, one of imports, the other of domestic brands or grade fresh fruit for various standards (i.e., Grade A or Extra Fancy).

___ - ___ 3. Determining the classification of a complex visual item by a specified attribute. Sort 10 patients into three groups, based on the level of medical attention required, based on the patient's physical appearance.

F - C

C. CONVERGENT PRODUCTION OF VISUAL RELATIONS:

___ - ___ 1. Specifying simple relationships among a few distinct visual forms to satisfy a specific requirement. Given five polygons, specify which (if any) are related based on the number of sides.

___ - ___ 2. Specifying more involved relationships among a few moderately complex visual forms to satisfy a specific requirement. Given six photographs of single-family dwellings, specify which (if any) are related based on type of construction (i.e., brick, frame, stucco, etc.).

___ - ___ 3. Specifying complex relationships among a few complex visual forms to satisfy a specific requirement. Given four aerial reconnaissance photographs of a suspected missile battery, specify the relationships of the various objects in the photographs to one another.

F - C

D. CONVERGENT PRODUCTION OF VISUAL SYSTEMS:

___ - ___ 1. Producing the static arrangement and position a few simple visual forms to satisfy a specific requirement. Specifying the optimum arrangement of appliances in a kitchen based on the requirement of minimizing the distance between the appliances.

___ - ___ 2. Producing the arrangement and spatial position of several moderately complex objects to satisfy a specific requirement. Developing the optimum layout of machines and processes in a factory to achieve the greatest rate of production per operating hour.

___ - ___ 3. Producing the arrangement and spatial positions of members of a complex system of visual forms to satisfy a specific requirement. Directing the altitude and headings for all aircraft waiting to land at a busy airport to insure the safety of each aircraft.

F - C

E. CONVERGENT PRODUCTION OF VISUAL TRANSFORMATIONS:

___ - ___ 1. Decomposing a simple image and reconstructing it to conform to a specific requirement. Given 12 match sticks forming a square divided into quadrants (thereby creating five squares) remove any two matches to leave three squares.

___ - ___ 2. Decomposing a moderately complex image and reconstructing it to conform to a specific requirement. Revising a landscaping plan to incorporate more shade tree and fewer shrubs or specifying a new exterior body shape to accommodate a requirement for a lower coefficient of drag in an automobile design.

___ - ___ 3. Decomposing a complex image and reconstructing it to conform to a specific requirement. Attempting to identify enemy tanks and emplacements that are camouflaged or reconstructing a victim's facial features based on skeletal remains.

F - C

F. CONVERGENT PRODUCTION OF VISUAL IMPLICATIONS:

___ - ___ 1. Determining the information inherent in a simple visual scene. Following the directions of a simple sign (i.e., a policeman's extended arm implying "STOP").

___ - ___ 2. Determining the information inherent in a moderately complex visual scene. Seeing an open window with rain blowing in and closing the window or seeing smoke coming out of a house and calling the fire department.

___ - ___ 3. Determining the information inherent in a simple visual scene. Anticipating an erratic driver's swerving to avoid a head-on collision or determining the nature of patient's illness, based on a visual inspection of the patient

F - C

G. CONVERGENT PRODUCTION OF AUDITORY UNITS:

___ - ___ 1. Producing a simple, distinct, auditory stimulus to satisfy a specific requirement. Barking when asked how a dog sounds or playing a specific musical note.

___ - ___ 2. Producing a moderately complex auditory stimulus to satisfy a specific requirement. Playing a specific chord on an instrument.

___ - ___ 3. Producing a complex auditory stimulus to satisfy a specific requirement. Giving the correct pronunciation of a word.

F - C

H. CONVERGENT PRODUCTION OF AUDITORY CLASSES:

___ - ___ 1. Determining the classification of a simple auditory stimulus based on a specified attribute. Given a tone, specify if it belongs in one of several categories.

___ - ___ 2. Determining the classification of a moderately complex auditory stimulus based on a specified attribute. Given a piece of music, specify its general class (i.e., classical, pop, rock, gospel, etc.).

___ - ___ 3. Determining the classification of a complex auditory stimulus based on a specified attribute. Identifying a person by their voice or a specific animal by its call.

F - C

I. CONVERGENT PRODUCTION OF AUDITORY RELATIONS:

___ - ___ 1. Specifying simple relationships among a few distinct auditory stimuli to satisfy a specific requirement. Given five musical notes, specify which (if any) are related based on their key.

___ - ___ 2. Specifying more involved relationships among a few auditory stimuli to satisfy a specific requirement. Given six engine noises, specify which, (if any) is related to low oil pressure.

___ - ___ 3. Specifying complex relationships among a few complex auditory stimuli to satisfy a specific requirement. Given four operettas, specify which (if any) are related based on the style of musical composition or if any of three voices have the same regional accent.

F - C

J. CONVERGENT PRODUCTION OF AUDITORY SYSTEMS:

___ - ___ 1. Producing the arrangement and/or position of a few simple auditory stimuli to satisfy a specific requirement. Identifying a bugler's signal to charge or a simple drum cadence.

___ - ___ 2. Producing the arrangement of several moderately complex auditory stimuli to satisfy a specific requirement. Identifying some of the principle sounds in a busy bus station or interpreting an expected message on the telephone.

___ - ___ 3. Producing the arrangement and/or position of a complex system of auditory stimuli to satisfy a specific requirement. Identifying a radio communication that is partially jammed or identifying the position of a submarine from several auditory inputs.

F - C

K. CONVERGENT PRODUCTION OF AUDITORY TRANSFORMATIONS:

___ - ___ 1. Decomposing a simple sound and reconstructing it to conform to a specific requirement. Producing the result of increasing a 700 Hz tone by 200 Hz.

___ - ___ 2. Decomposing a moderately complex sound and reconstructing it to conform to a specific requirement. Producing the result of changing from a D-minor to a D-major chord.

___ - ___ 3. Decomposing a complex sound and reconstructing it to conform to a specific requirement. An impressionist changing his voice to sound like a famous actor.

F - C

L. CONVERGENT PRODUCTION OF AUDITORY IMPLICATIONS:

___ - ___ 1. Determining the information inherent in a simple auditory stimulus. Following the directions of a simple sound (i.e., stopping at a railroad crossing after hearing the warning bell).

___ - ___ 2. Determining the information inherent in a moderately complex auditory stimulus. Hearing a sputtering lawn-mower engine and knowing it needs a tune-up.

___ - ___ 3. Determining the information inherent in a complex auditory stimulus. Determining the emotions implied in a moving piece of music or the seriousness of a patient's lung ailment based on the sound of his breathing.

F - C

M. CONVERGENT PRODUCTION OF SYMBOLIC UNITS:

___ - ___ 1. Producing a simple, distinct, symbol to satisfy a specific requirement. Producing a plus (+) sign when asked for the operator depicting addition.

___ - ___ 2. Producing a moderately complex symbol to satisfy a specific requirement. Producing the symbol representing Chrysler Corporation when asked for its company logo.

___ - ___ 3. Producing a complex symbol to satisfy a specific requirement. Producing the Declaration of Independence when asked for the symbol of the United States' formal break with England.

F - C

N. CONVERGENT PRODUCTION OF SYMBOLIC CLASSES:

___ - ___ 1. Determining the classification of a simple symbol based on a specified attribute. Given a pound sign (#), specify if it can be used as a mathematic operator.

___ - ___ 2. Determining the classification of a simple symbol based on a specified attribute. Given a company logo, specify its general industrial class (i.e., steel, aerospace, pharmaceuticals, etc.) or given a national flag identify the name of its country.

___ - ___ 3. Determining the classification of a simple symbol based on a specified attribute. Given the name of a place (i.e., Bunker Hill) determine if the place is of patriotic significance.

F - C

O. CONVERGENT PRODUCTION OF SYMBOLIC RELATIONS:

___ - ___ 1. Completing a simple symbolic relationship. Given a sequence of three numbers (1, 3, 5) specify which number logically follows (7).

___ - ___ 2. Completing a more involved symbolic relationship. Breaking a simple code or applying rules for spelling words.

___ - ___ 3. Completing a complex symbolic relationship. Given a brief line or term (i.e., "separate but equal" or "I have a dream") identify the relationship of those terms or deciphering a complex code.

F - C

P. CONVERGENT PRODUCTION OF SYMBOLIC SYSTEMS:

___ - ___ 1. Producing a simple, completely structured order of symbols to satisfy a specific requirement. Developing a simple identification system such as alphabetizing names on a list.

___ - ___ 2. Producing a moderately complex, completely structured order of symbols to satisfy a specific requirement. Writing a crossword puzzle given a set of words or developing a ZIP code system.

___ - ___ 3. Producing a complex, completely structured order of symbols to satisfy a specific requirement. Designing a complex code for transmitting sensitive or top-secret information of national importance.

F - C

Q. CONVERGENT PRODUCTION OF SYMBOLIC TRANSFORMATIONS:

___ - ___ 1. Producing new symbolic elements of information by revising a given basic symbol to meet a specified requirement. Finding the name of a given object (i.e., ball) hidden in a sentence (i.e., "We saw the dancer throw a baton at the BALLet").

___ - ___ 2. Producing new symbolic elements of information by revising a given, moderately complex symbol to meet a specified requirement. Updating a given symbol (i.e., a green aircraft) on a map to reflect its current status (changing the color from green to yellow to indicate low fuel).

___ - ___ 3. Producing new symbolic elements of information by revising a given complex symbol to meet a specified requirement. Producing a new symbol (i.e., company logo) to reflect changes in the company.

F - C

R. CONVERGENT PRODUCTION OF SYMBOLIC IMPLICATIONS:

___ - ___ 1. Producing a unambiguous symbolic deduction from given basic symbolic information in a novel or unpracticed context. Applying mathematics to develop a personal budget (given that one has never used a budget) or using blueprint plans to construct a simple piece of furniture.

___ - ___ 2. Producing a unambiguous symbolic deduction from given moderately complex symbolic information in a novel or unpracticed context. Applying calculus to solve an engineering problem or sight-reading a piece of music for the first time.

___ - ___ 3. Producing a unambiguous symbolic deduction from given complex symbolic information in a novel or unpracticed context. Determining the correct surgical approach for a previously unencountered injury or applying quantum theory to predict the behavior of particles in a particular chemical reaction.

F - C

S. CONVERGENT PRODUCTION OF SEMANTIC UNITS:

___ - ___ 1. Producing an appropriate object or idea to summarize a given basic concept. Answering a crossword puzzle clue (i.e., a five-letter word for "noontime meal" - lunch) or specifying the proper tool in a basic carpentry job.

___ - ___ 2. Producing an appropriate object or idea to summarize a given moderately complex concept. Indicating a micro-computer system that is suitable for a particular business operation or selecting a house that meets the needs of a family.

___ - ___ 3. Producing an appropriate object or idea to summarize a given complex concept. Specifying a word when asked to describe someone with "just one word" or an evaluator assigning a single rating to a multi-billion dollar bid proposal for a new superhighway (i.e., "acceptable" or "unacceptable).

F - C

T. CONVERGENT PRODUCTION OF SEMANTIC CLASSES:

___ - ___ 1. Producing meaningful classes of simple objects or concepts to satisfy a specific condition(s). Grouping nine given words in only three categories, with no words left over or specifying the general class of a group of objects.

___ - ___ 2. Producing meaningful classes of moderately complex objects or concepts to satisfy a specific condition(s). Given a group of four items, divide then into three more specific classes.

___ - ___ 3. Producing meaningful classes of complex objects or concepts to satisfy a specific condition(s). Given the same four items as above, specify an even more precise class (such as the model and year for automobiles).

F - C

U. CONVERGENT PRODUCTION OF SEMANTIC RELATIONS:

___ - ___ 1. Specifying an idea or concept that satisfies a given, simple, relationship. Pronounce the antonym of a given word given the first letter or determine a word similar in meaning to two other words.

___ - ___ 2. Specifying an idea or concept that satisfies a given, moderately complex relationship. Given the words "father,son, mother," determine the completing word.

___ - ___ 3. Specifying an idea or concept that satisfies a given, complex, relationship. Developing a theory to explain complex physical phenomenon (i.e., the theory of relativity was developed to explain the relationship of matter and energy).

F - C

V. CONVERGENT PRODUCTION OF SEMANTIC SYSTEMS:

___ - ___ 1. Integrating three or more concepts in a meaningful, simple, sequence. Developing the rules of a simple game or creating a simple sentence to convey a specific meaning (i.e., "Close the door").

___ - ___ 2. Integrating three or more concepts in a meaningful, moderately complex, sequence. Given five scrambled pictures from a comic, indicate the order that makes sense or order several given sentences in a meaningful way.

___ - ___ 3. Integrating three or more concepts in a meaningful, complex, sequence. Specify the temporal sequence of steps needed to execute a complex plan (i.e., manufacturing a new product).

F - C

W. CONVERGENT PRODUCTION OF SEMANTIC TRANSFORMATIONS:

___ - ___ 1. Determining novel applications of simple objects and concepts by removing them from their traditional contexts and redefining them to satisfy a specified purpose. Given three simple objects (a broom, a box, and a plate) choose one to retrieve a kite caught in a small tree.

___ - ___ 2. Determining novel applications of moderately complex objects and concepts by removing them from their traditional contexts and redefining them to satisfy a specified purpose. Placing four-wheel drive transmissions in passenger cars to increase traction and versatility or adapting a standard course to a new clientele.

___ - ___ 3. Determining novel applications of complex objects and concepts by removing them from their traditional contexts and redefining them to satisfy a specified purpose. Synthesizing a new product from two existing products (i.e., combining the power of the computer and laser printers to create "desktop publishing") or combining the qualities of spacecraft and aircraft to create the Space Shuttle.

F - C

X. CONVERGENT PRODUCTION OF SEMANTIC IMPLICATIONS:

___ - ___ 1. Deducing meaningful information inherent in a given simple concept or situation. Given a specific event and context, specify the appropriate event which immediately follows.

___ - ___ 2. Deducing meaningful information inherent in given moderately complex concept or situation. While flying, the pilot notices his number two engine has failed; he then executes emergency procedures to restart the engine.

___ - ___ 3. Deducing meaningful information inherent in a given complex concept or situation. Reading a book and appreciating its themes or military intelligence officers examining many sources of data on enemy troop movements and exercises to determine their readiness and intentions.

F - C

Y. CONVERGENT PRODUCTION OF BEHAVIORAL UNITS:

___ - ___ 1. Producing a simple, distinct, behavioral action to satisfy a given requirement. Determining the appropriate response in an unambiguous social situation, such as shaking hands when you are introduced to someone who offers their hand.

___ - ___ 2. Producing a moderately complex behavioral action to satisfy a given requirement. Making a toast at a wedding reception when asked to do so.

___ - ___ 3. Producing a complex behavioral action to satisfy a given requirement. As an actress, portraying a woman who has just received news that her husband has been killed in action during wartime.

F - C

Z. CONVERGENT PRODUCTION OF BEHAVIORAL CLASSES:

___ - ___ 1. Producing meaningful classes of simple behaviors to satisfy a specific condition(s). Grouping five basic behaviors in only two categories or specifying the general class of a group of behaviors.

___ - ___ 2. Producing meaningful classes of moderately complex behaviors to satisfy a specific condition(s). Given a group of six social events, divide them into three specific classes, placing each in only one class (i.e., family events, office events, and political events).

___ - ___ 3. Producing meaningful classes of complex behaviors to satisfy a specific condition(s). Given five different wars, classify each as either a limited-war or an all-out war.

F - C

AA. CONVERGENT PRODUCTION OF BEHAVIORAL RELATIONS:

___ - ___ 1. Specifying a behavior appropriate to a given, concrete, relationship. A butler determining the correct manner to greet his employer.

___ - ___ 2. Specifying a behavior appropriate to a given, moderately complex, relationship. A manager determining the correct manner to greet a colleague from another division of the same company.

___ - ___ 3. Specifying a behavior appropriate to a given, complex, relationship. A head of state (and her staff) determining the proper manner of greeting a visiting head of state from a rival nation.

F - C

BB. CONVERGENT PRODUCTION OF BEHAVIORAL SYSTEMS:

___ - ___ 1. Integrating three or more behaviors in a meaningful, simple, sequence to achieve a specified goal. Deciding the actions required to complete a simple task (i.e., the steps needed to clean the house).

___ - ___ 2. Integrating three or more behaviors in a meaningful, moderately complex, sequence to achieve a specified goal. Planning how a stage crew will change the scenery between acts of a play or developing the schedule for a national conference of a professional society.

___ - ___ 3. Integrating three or more behaviors in a meaningful, complex, sequence to achieve a specified goal. Coordinating a major military maneuver (i.e., the D-Day Invasion) or determining the necessary movements to catch a thrown ball.

F - C

CC. CONVERGENT PRODUCTION OF BEHAVIORAL TRANSFORMATIONS:

___ - ___ 1. Determining novel applications of simple behaviors by removing them from their traditional contexts and redefining them to satisfy a specified purpose. When building a shelf, a carpenter notices that a modification of a joint he uses in securing ceiling beams can be used to join shelf supports.

___ - ___ 2. Determining novel applications of moderately complex behaviors by removing them from their traditional contexts and redefining them to satisfy a specified purpose. Determining how a previously successful problem solving approach can be modified to solve a current problem.

___ - ___ 3. Determining novel applications of complex behaviors by removing them from their traditional contexts and redefining them to satisfy a specified purpose. A psychiatrist tailoring a standard therapeutic technique for the unique needs of his patient.

F - C

DD. CONVERGENT PRODUCTION OF BEHAVIORAL IMPLICATIONS:

___ - ___ 1. Deducing meaningful information inherent in a given simple behavioral situation. Determining that a person is sad because he is sobbing or that an audience approves of an entertainer's performance given a standing ovation is observed.

___ - ___ 2. Deducing meaningful information inherent in given moderately complex behavioral situation. As a defensive player, attempting to determine the real intent of opposing players while they execute a "decoy" play designed to fool the defense.

___ - ___ 3. Deducing meaningful information inherent in a given complex behavioral situation. Determining a child has been emotionally abused based on his actions and answers to diagnostic test questions or determining the mood of stockholders regarding an attempted hostile takeover of the company.

SECTION 5. EVALUATION. This operation involves reaching decisions or making assessments relative to some criterion. This can include judgements regarding correctness, identity, adequacy, consistency, desirability, or other attributes of information. Examples of this operation include determining if a proposed highway will interfere with animal migration patterns, if a glass will hold the entire contents of a beverage container, and if a Macintosh apple belongs to the class of firm, red, edible objects.

YES____ (answer remaining questions) NO____ (stop)

F - C

A. EVALUATION OF VISUAL UNITS:

___ - ___ 1. Judging a simple, distinct, visual form as being similar or different to each other or a specified standard. Given two shapes, evaluate their similarity or compare a given shape to a target shape.

___ - ___ 2. Judging a moderately complex visual form as being similar or different to each other or a specified standard. Given two kitchen utensils, evaluate their similarity or compare a given appliance to a target appliance.

___ - ___ 3. Judging a complex visual form as being similar or different to each other or a specified standard. Given two automobiles, evaluate their similarity or compare a given style of architecture to a desired (target) style of architecture.

F - C

B. EVALUATION OF VISUAL CLASSES:

___ - ___ 1. Evaluating the classification of a non-complex visual item based on a specified, well-defined, attribute. Given a group of five cans with crooked labels (marked "failed") determine the classification rule and apply it to evaluate other cans.

___ - ___ 2. Evaluating the classification of a moderately complex visual item based on a specified attribute. Given a stack of lumber for interior woodwork (marked "top grade") determine the classification rule based on grain, lack of knots, finish, straightness, etc., and apply it to grade other stacks of lumber.

___ - ___ 3. Evaluating the classification of a complex visual item based on a specified attribute. Given several examples of "great art masterpieces," determine the classification rule and apply it to other works of art.

F - C

C. EVALUATION OF VISUAL RELATIONS:

___ - ___ 1. Judging given, simple relationships among a few distinct visual forms, relative to a specified standard. Evaluating the placement of plates and utensils at a table to serve five people at dinner or arrangement of books on a shelf from taller books on the left to shorter books to the right.

___ - ___ 2. Judging given, more involved relationships among a few visual forms, relative to a specified standard. Evaluating the symmetry of pictures hung on a wall or the relationship of frequently used controls to each other on an automobile dashboard.

___ - ___ 3. Judging given, complex relationships among a few potentially ambiguous visual forms and dimensions, relative to a specified standard. Evaluating the suitability of a given color scheme for decorating a new living room to convey a desired mood.

F - C

D. EVALUATION OF VISUAL SYSTEMS:

___ - ___ 1. Analyzing the static arrangement and position a few simple visual forms conforming to a specified requirement. Evaluating a given arrangement of appliances in a kitchen designed to reduce the workload on the cook.

___ - ___ 2. Analyzing the arrangement and spatial position of several moderately complex objects conforming to a specified requirement. Appraising the suitability of a houseplan to accommodate a family's specific needs.

___ - ___ 3. Analyzing the arrangement and spatial positions of members of a complex system of visual forms conforming to a specified requirement. Appraising the positions of all aircraft in a holding pattern over a busy airport to insure adequate spacing for each aircraft.

F - C

E. EVALUATION OF VISUAL TRANSFORMATIONS:

___ - ___ 1. Appraising the impact of some specific change on a simple visual object. Judging that a block or some other simple object has rotated 270 degrees or than an object on a desk has been moved.

___ - ___ 2. Appraising the impact of several changes in a moderately complex visual scene or object. Judging if several different perspective views are of the same boat.

___ - ___ 3. Appraising the impact of subtle changes in a complex visual scene or object. Judging the cause of an aircraft accident based on visual inspection of the crash site and wreckage.

F - C

F. EVALUATION OF VISUAL IMPLICATIONS:

___ - ___ 1. Judging the consequences inherent in a simple visual scene given a specific standard. Evaluating if a particular stove burner is hot given that hot burners are orange in color.

___ - ___ 2. Judging the consequences inherent in a possibly ambiguous visual scene. Evaluating a route to get from Boston to Miami with the goal being to travel the fewest miles.

___ - ___ 3. Judging the consequences in an ambiguous visual scene given a specific standard. Evaluating an intercept route for docking a spacecraft with another moving craft, when the goal is to dock safely using the least amount of fuel.

F - C

G. EVALUATION OF AUDITORY UNITS:

___ - ___ 1. Judging a simple, distinct, auditory stimulus as being similar or different to each other or a specified standard. Evaluating the similarity of two tones or if a sound is similar to a target.

___ - ___ 2. Judging a moderately complex auditory stimulus as being similar or different to each other or a specified standard. Evaluating whether or not a dog's bark is of a specified breed or if a car horn is of a particular model.

___ - ___ 3. Judging a complex auditory stimuli as being similar or different to each other or a specified standard. Evaluating if a spoken word matches a target word or how well a professional singer reproduces a specified song.

F - C

H. EVALUATION OF AUDITORY CLASSES:

___ - ___ 1. Evaluating the classification of a non-complex auditory stimulus based on a specified, well-defined, attribute. Determining if given tones should be classed as "sounds less than 5,000 Hz" or "sounds between 10 and 10,000 decibels".

___ - ___ 2. Evaluating the classification of a moderately complex visual item based on a specified attribute. Determining the appropriateness of classifying a dog's bark as loud or soft.

___ - ___ 3. Evaluating the classification of a complex visual item based on a specified attribute. Determining the appropriateness of classifying a particular musical piece as being composed by

Chopin or classifying a specific submarine's sonar return as an "Alfa" class ship.

F - C

I. EVALUATION OF AUDITORY RELATIONS:

___ - ___ 1. Judging given, simple relationships among a few distinct auditory stimuli, relative to a specified criteria. Given two notes, evaluating them in terms of octave differential or the relative loudness or softness of each of the tones in decibels.

___ - ___ 2. Judging given, more involved relationships among a few auditory stimuli, relative to a specified criteria. Selecting the best voice among several who audition based on range, volume, and tonal quality.

___ - ___ 3. Judging given, complex relationships among a few potentially ambiguous auditory stimuli. Given two melodies, select the one which is "more pleasing."

F - C

J. EVALUATION OF AUDITORY SYSTEMS:

___ - ___ 1. Analyzing the integration of a few simple sounds to form a unique whole. Appraising a bugler's signal to charge or a simple drum cadence.

___ - ___ 2. Analyzing the integration of several moderately complex sounds. Identifying some of the principle sounds in a busy bus station or interpreting an expected message on the telephone.

___ - ___ 3. Analyzing the arrangement and position of various stimuli in a complex auditory system with varying degrees of background clutter. Appraising a radio communication that is partially jammed or identifying the position of a submarine from several auditory inputs.

F - C

K. EVALUATION OF AUDITORY TRANSFORMATIONS:

___ - ___ 1. Appraising the impact of changes on a simple auditory stimulus after some specific changes occur. Judging a tone has increased in pitch or a steady tone is now wavering.

___ - ___ 2. Appraising the result of several changes imposed on a moderately complex auditory arrangement. Determining the impact of changing the key of a musical selection or the effect of increasing the tempo of spoken words on intelligibility.

___ - ___ 3. Appraising the impact of subtle changes in a complex auditory system. Judging verbal commands made by a pilot under high-g stress or interpreting words that are sung rather than spoken.

F - C

L. EVALUATION OF AUDITORY IMPLICATIONS:

___ - ___ 1. Judging suitability of the consequences inherent in a simple auditory stimulus to satisfy a given criteria. Evaluating the adequacy of a fire alarm to rouse sleeping tenants or the adequacy of a warning horn to alert the pilot to an inoperative subsystem.

___ - ___ 2. Judging suitability of the consequences inherent in a moderately complex auditory stimulus to satisfy a given criteria. Evaluating the sound of a train in the night to determine if it is approaching or receding or determining if a dishwasher is operating correctly by its sound.

___ - ___ 3. Judging suitability of the consequences inherent in a complex auditory stimulus to satisfy a given criteria. Evaluating the performance of a symphony orchestra to determine if additional practice is required.

F - C

M. EVALUATION OF SYMBOLIC UNITS:

___ - ___ 1. Making rapid judgements regarding identification of a simple, distinct, symbol relative to a specified criteria. Judging that two given numbers are the same or different or selecting all words in a list containing the letter "d."

___ - ___ 2. Making judgements regarding identification of moderately complex symbols relative to a specified criteria. Selecting all symbols on a map of cities with populations greater than 50,000 people.

___ - ___ 3. Making judgements regarding identification of complex symbols relative to a specified criteria. Selecting key words from a handwritten note.

F - C

N. EVALUATION OF SYMBOLIC CLASSES:

___ - ___ 1. Judging the applicability of class properties for a given simple symbol based on a specified criteria. Given a number (i.e., 2) and several classes with associated point values (i.e., primes = 4 points, even = 2 points, odd = 1 point), classify the number to achieve the most points (i.e., primes).

___ - ___ 2. Judging the applicability of class properties for a given moderately complex symbol based on specified criteria. Given a specific version of a new product logo, determine its suitability for projecting the desired image to the target market.

___ - ___ 3. Judging the applicability of class properties for a given complex symbol based on specified criteria. Given a person with a specific status symbol (i.e., a BMW), determine the suitability of that person as typical of the people evoked by the symbol.

F - C

O. EVALUATION OF SYMBOLIC RELATIONS:

___ - ___ 1. Ascertaining the consistency and similarity among simple relationships composed of a few distinct symbols. Determining if the conclusion of specified by a symbolic equation is true or false (i.e., 5 - 4 = 9).

___ - ___ 2. Ascertaining the consistency and similarity of more involved relationships composed of several symbols. Determining if a given passage uses consistent verb tense.

___ - ___ 3. Ascertaining the consistency and similarity of complex relationships composed of many symbols. Determining the truth of a mathematical proof by verifying all the supporting calculations.

F - C

P. EVALUATION OF SYMBOLIC SYSTEMS:

___ - ___ 1. Estimating the suitability of aspects of a simple symbolic system to satisfy a given requirement. Given a few numbers (i.e., 102, 945, 256, 220) judge which number is most unlike the other three or given six letters (i.e., a, c, e, o, u, i) specify the letter that does not belong.

___ - ___ 2. Estimating the suitability of aspects of a moderately complex symbolic system to satisfy a given requirement. Determining the quality (measured as resistance to being broken by an enemy) of a military code.

___ - ___ 3. Estimating the suitability of aspects of a complex symbolic system to satisfy a given requirement. Determining the suitability of one language over another for communicating scientific information.

F - C

Q. EVALUATION OF SYMBOLIC TRANSFORMATIONS:

___ - ___ 1. Judging if a specific ordering of simple, substitute symbols is adequate to convey the original information. Determining if specific words can be made by rearranging the letters of a given word.

___ - ___ 2. Judging if a specific ordering of moderately complex, substitute symbols is adequate to convey the original information. Determining which of several label designs most accurately depicts the dangers and warnings associated with a product.

___ - ___ 3. Judging if a specific ordering of complex, substitute symbols is adequate to convey the original information. Determining the degree of consistency and accuracy in translating written material from Russian to English (meaning is not involved).

F - C

R. EVALUATION OF SYMBOLIC IMPLICATIONS:

___ - ___ 1. Evaluating the probability or inferences drawn from given simple symbolic information. Given a simple symbol, select which of three objects it best represents or given an abbreviation select the word it best represents from four alternatives.

___ - ___ 2. Evaluating the probability or inferences drawn from given moderately complex symbolic information. Evaluating how far your car can go once you see the "FUEL LOW" warning lamp on the dashboard or evaluating the outcome of selling or holding a particular stock based on its climbing price over several days.

___ - ___ 3. Evaluating the probability or inferences drawn from given complex symbolic information. Select the best symbol to represent the United Nations from several given candidates or based on the position of various symbols on a military tactical battlefield display, determine the probability of achieving an objective.

F - C

S. EVALUATION OF SEMANTIC UNITS:

___ - ___ 1. Judging the suitability a simple idea or concept to satisfy a given requirement. Evaluating the meaning of non-complex domain elements such as "dog," "car," "bed," when used in their correct context.

___ - ___ 2. Judging the suitability of a moderately complex idea or concept to satisfy a given requirement. Evaluating the meaning of less-general domain terms such as "too hot," "sell-short," or other potentially ambiguous concepts or jargon for use in a given context.

___ - ___ 3. Judging the suitability of a complex idea or concept to satisfy a given requirement. Evaluating meanings of abstract terms like "love," "beautiful," or other highly subjective concepts for use in a given context.

F - C

T. EVALUATION OF SEMANTIC CLASSES:

___ - ___ 1. Judging the applicability of class properties for a given simple idea or concept based on a specified criteria. Given three classes (i.e., citrus, fruit, plant) select the one that best applies to a given object (i.e., an orange).

___ - ___ 2. Judging the applicability of class properties for a given moderately complex idea or concept based on a specified criteria. Given three job titles (i.e., trash collector, sanitation engineer, or city-street custodian, select the one that best applies to a particular job.

___ - ___ 3. Judging the applicability of class properties for a given simple idea or concept based on a specified criteria. Given three properties (i.e., complex, practical, and methodical) select the one least descriptive of a particular concept (i.e., philosophy).

F - C

U. EVALUATION OF SEMANTIC RELATIONS:

___ - ___ 1. Deciding among simple, concrete relationships among a few concepts or situations based upon obvious similarities in their meanings. Identifying simple trends in data (or themes in text) or completing simple analogies (SIT is to CHAIR as LAY is to BED).

___ - ___ 2. Ascertaining less certain relationships among a few concepts based upon their general similarity. Evaluating the relationship between violence on television and juvenile delinquency or the relative impact of education on preventing teen pregnancy.

___ - ___ 3. Ascertaining complex relationships among potentially ambiguous concepts or ideas, which may also have dissimilar meanings.

F - C

U. EVALUATION OF SEMANTIC SYSTEMS:

___ - ___ 1. Analyzing the internal consistency of three or more integrated unambiguous concepts which comprise a unique whole. Deciding if a set of rules for a game is consistent or if the procedures for handling employee grievances are equitable to all.

___ - ___ 2. Analyzing the internal consistency of several moderately complex integrated concepts in potentially ambiguous contexts. Judging the reading-level required to understand a newspaper article or the consistency of a contract to purchase a medium-sized weapon system.

___ - ___ 3. Analyzing the internal consistency of many complex integrated concepts in generally ambiguous contexts. Appraising the consistency of themes in a literary classic or the consistency of topics in a politician's speech.

F - C

V. EVALUATION OF SEMANTIC TRANSFORMATIONS:

___ - ___ 1. Appraising the suitability of an object or idea to satisfy specific changes imposed on a simple conceptual system or situation. Given four tools (not primarily used for the current task), concluding which tool could best accomplish the task with minimal modification.

___ - ___ 2. Appraising the suitability of an object or idea to satisfy specific changes imposed on a moderately complex conceptual system. Concluding the desirability of certain design changes to meet new system specifications or assessing the viability of a proposed method of providing mass transportation for a growing community.

___ - ___ 3. Appraising the suitability of an object or idea to satisfy subtle or major changes in a complex conceptual system or situation. Appraising the organizational changes needed to implement a new long-range strategy or deciding the outcomes of adopting a new advertising strategy for a revised product.

F - C

X. EVALUATION OF SEMANTIC IMPLICATIONS:

___ - ___ 1 Judging the suitability of a conclusion based upon complete and unambiguous information. Evaluating the desirability of buying product A or product B based upon a complete examination of the pros and cons or each product.

___ - ___ 2. Judging the suitability of a conclusion based upon generally complete and moderately complex semantic information. Estimating the probability of success of recommending launch of a rocket under some known weather conditions and launch-window characteristics.

___ - ___ 3. Judging the suitability of a conclusion based upon generally incomplete and ambiguous semantic information. Deciding national fiscal policy based upon leading economic indicators or the repercussions of unilateral nuclear disarmament.

F - C

Y. EVALUATION OF BEHAVIORAL UNITS:

___ - ___ 1. Judging the appropriateness of a simple, distinct, behavioral action in a non-complex situation. Analyzing the appropriateness of a smile, a wink, or a salute.

___ - ___ 2. Judging the appropriateness of a moderately complex behavioral action in a situation with some degree of ambiguity.

___ - ___ 3. Judging the appropriateness of a complex behavioral action in a situation with some degree of ambiguity. Identifying correct behaviors or responses in a novel situation, such as how to respond upon being the first to arrive at a massive automobile pile-up with many injuries.

F - C

Z. EVALUATION OF BEHAVIORAL CLASSES:

___ - ___ 1. Evaluating the classifications of behavioral items by a few simple or readily apparent attributes. Given a set of facial expressions and descriptions of each, assess the appropriateness of the description for each expression.

___ - ___ 2. Judging the classification of a moderately complex behavioral activities on several potentially ambiguous or not readily apparent dimensions.

___ - ___ 3. Evaluating the classification of complex behavioral activities on several potentially ambiguous or not readily apparent dimensions. Deciding if a particular version of choreography evokes the correct emotion or if group of vociferous demonstrators can be classified as a "mob" requiring police control.

F - C

AA. EVALUATION OF BEHAVIORAL RELATIONS:

___ - ___ 1. Ascertaining simple relationships among a few distinct behavioral actions or situations. Evaluating one's basic roles in a family (mother, wife, and breadwinner, could describe the basic roles of a woman in a family) or the relative standing of two politicians on a particular issue.

___ - ___ 2. Ascertaining moderately complex relationships among potentially ambiguous behavioral actions or situations.

___ - ___ 3. Ascertaining complex relationships among potentially ambiguous behavioral actions or situations. Appraising an organization's status within in industry (such as AT&T in the communications industry) and the power associated with that status.

F - C

BB. EVALUATION OF BEHAVIORAL SYSTEMS:

___ - ___ 1. Analyzing the consistency of interactions in a simple social system. Determining if certain actions always result in certain outcomes.

___ - ___ 2. Analyzing the consistency of interactions in a moderately complex social system. Assessing the consistency of a a person's words and their body language (i.e., does the mouth say one thing while the body says the opposite?).

___ - ___ 3. Analyzing the interactions and acceptable actions in a complex social system with varying degrees of ambiguity. Appraising the consistency of a nation's rhetoric and their record on the issues.

F - C

CC. EVALUATION OF BEHAVIORAL TRANSFORMATIONS:

___ - ___ 1. Re-evaluating a simple action to alter its behavioral value. Deciding the appropriateness of a particular action (i.e., telling an off-color joke) given alternative settings (i.e., a locker room or a formal dinner party).

___ - ___ 2. Re-evaluating the impact of changes in a moderately complex behavioral activity. Determining if changing a particular behavior (i.e., style of dress) will result in a positive outcome (i.e., gaining more respect).

___ - ___ 3. Re-evaluating the impact of subtle or major changes in a complex behavioral activity. Judging how an ally may react based upon a change in financial aid to that ally or reconsidering a verdict based upon new evidence.

F - C

DD. EVALUATION OF BEHAVIORAL IMPLICATIONS:

___ - ___ 1. Judging the possible consequences suggested in a distinct behavioral action. Judging if a smile signifies permission to approach or assessing the audience's interest in your topic by the number of closed eyes and open mouths.

___ - ___ 2. Appraising the probability or consistency of possible consequences in a moderately ambiguous behavioral activity or situation. Determining the possible outcomes implied by the "boss" inviting you to dinner (i.e., you may be receiving a raise or you may have been selected for an undesirable assignment).

___ - ___ 3. Appraising the probability or consistency of possible consequences in an ambiguous behavioral activity or situation. Deciding the chances of getting your boss to give you a raise or the probabilities of success associated with alternative responses to an adversary's aggressive act.

APPENDIX B. DEBUGGING DOMAIN DSAT DATA

APPENDIX B1

DEBUGGING DOMAIN DSAT DATA

LEVEL ZERO DATA SUMMARY

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	10	10	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B I CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C S RELS	6.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D U SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	8.0	8.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	10	3.3	6.0	8.0	3.3	6.0	6.0	3.3	8.0	8.0	3.3	8.0	8.0	3.3
N Y CLSS	8.0	8.0	6.7	4.0	4.0	3.3	2.0	2.0	3.3	8.0	8.0	3.3	6.0	6.0	3.3
O M RELS	6.0	8.0	6.7	8.0	8.0	3.3	6.0	6.0	3.3	6.0	8.0	6.7	10	10	3.3
P B SYST	8.0	6.0	10	6.0	6.0	3.3	6.0	6.0	3.3	4.0	4.0	3.3	4.0	4.0	3.3
Q O TRNS	4.0	6.0	3.3	6.0	6.0	3.3	2.0	2.0	3.3	4.0	4.0	3.3	6.0	6.0	3.3
R L IMPL	6.0	6.0	3.3	6.0	8.0	3.3	2.0	4.0	3.3	2.0	2.0	3.3	4.0	4.0	3.3
OPER AVG	7.0	7.3	5.6	6.0	6.7	3.3	4.0	4.3	3.3	5.3	5.7	3.9	6.3	6.3	3.3
S S UNTS	6.0	6.0	3.3	4.0	6.0	3.3	2.0	4.0	3.3	6.0	6.0	3.3	4.0	6.0	3.3
T E CLSS	4.0	4.0	3.3	4.0	4.0	3.3	4.0	4.0	3.3	4.0	6.0	3.3	6.0	4.0	3.3
U M RELS	8.0	8.0	3.3	6.0	8.0	3.3	4.0	2.0	3.3	2.0	2.0	3.3	4.0	4.0	3.3
V A SYST	6.0	6.0	3.3	8.0	8.0	3.3	4.0	4.0	3.3	6.0	6.0	3.3	4.0	4.0	3.3
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	4.0	4.0	3.3	6.0	6.0	3.3	10	10	3.3	6.0	6.0	3.3	4.0	4.0	3.3
OPER AVG	5.6	5.6	3.3	5.6	6.4	3.3	4.8	4.8	3.3	4.8	5.2	3.3	4.4	4.4	3.3
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LEVEL TWO DATA SUMMARY

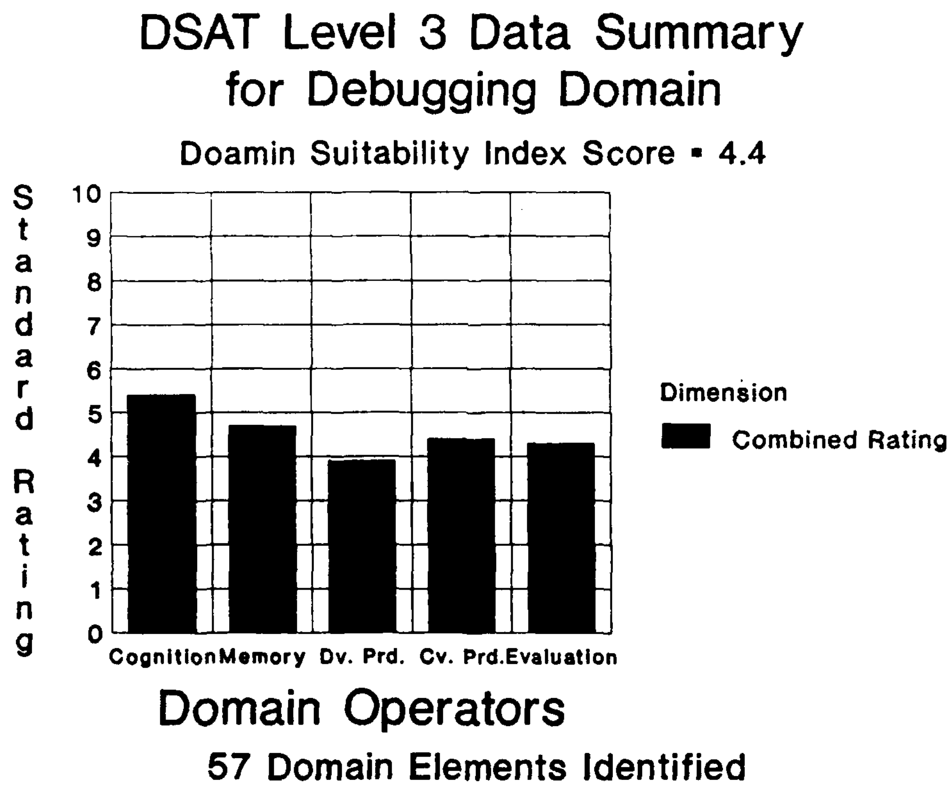
	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
CONTENT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
VISUAL	8.0	8.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AUDITORY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SYMBOLIC	7.0	7.3	5.6	6.0	6.7	3.3	4.0	4.3	3.3	5.3	5.7	3.9	6.3	6.3	3.3
SEMANTIC	5.6	5.6	3.3	5.6	6.4	3.3	4.8	4.8	3.3	4.8	5.2	3.3	4.4	4.4	3.3
BEHAVORAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	6.9	7.0	4.1	5.8	6.5	3.3	4.4	4.6	3.3	5.1	5.4	3.6	5.4	5.4	3.3

LEVEL THREE DATA SUMMARY

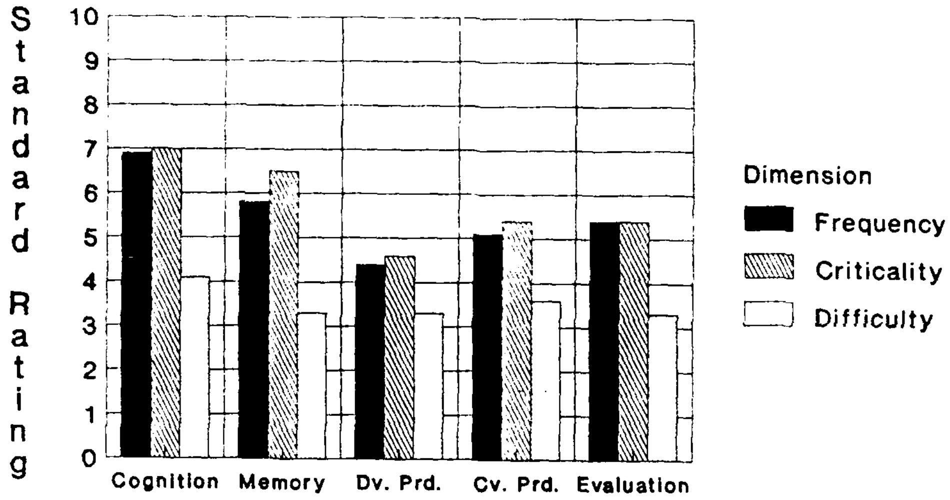
OPERATOR	F	C	D	N	FINAL RATING
COGNITION	6.9	7.0	4.1	13	5.4
MEMORY	5.8	6.5	3.3	11	4.7
DIVT. PROD.	4.4	4.6	3.3	11	3.9
CONV. PROD.	5.1	5.4	3.6	11	4.4
EVALUATION	5.4	5.4	3.3	11	4.3
DOMAIN AVERAGE	5.5	5.8	3.5	57	4.4

APPENDIX B2

DEBUGGING DOMAIN DSAT LEVEL 1, 2, AND 3 GRAPHS



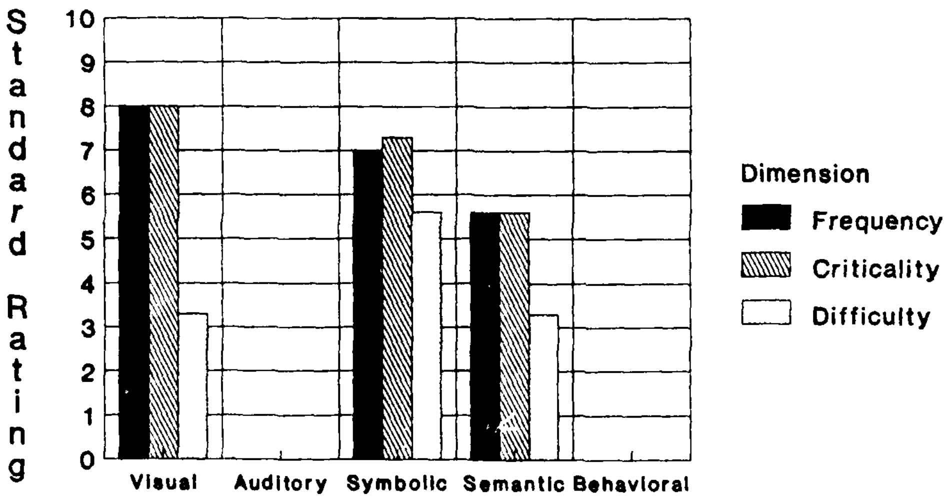
DSAT Level 2 Data Summary for Debugging Domain



Domain Operators

57 Domain Elements Identified

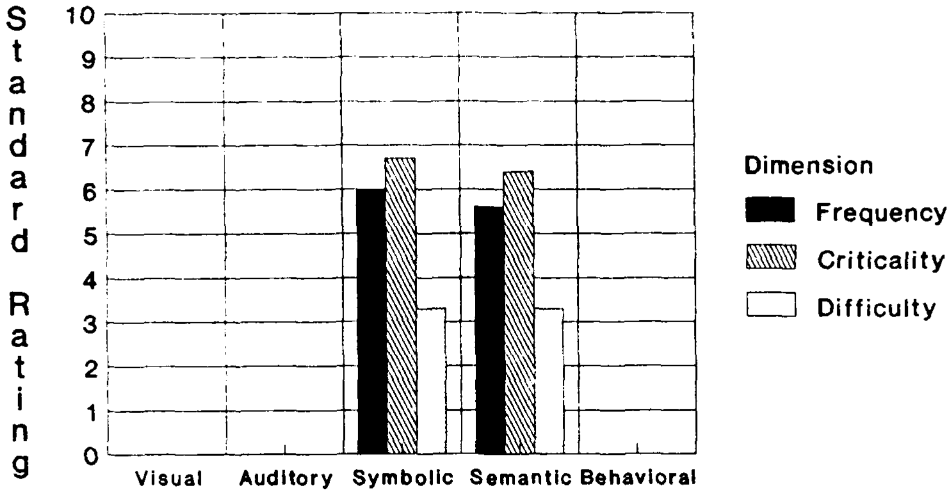
DSAT Level 1 - Cognition Operator for Debugging Domain



Domain Contents

13 Content-Products Identified

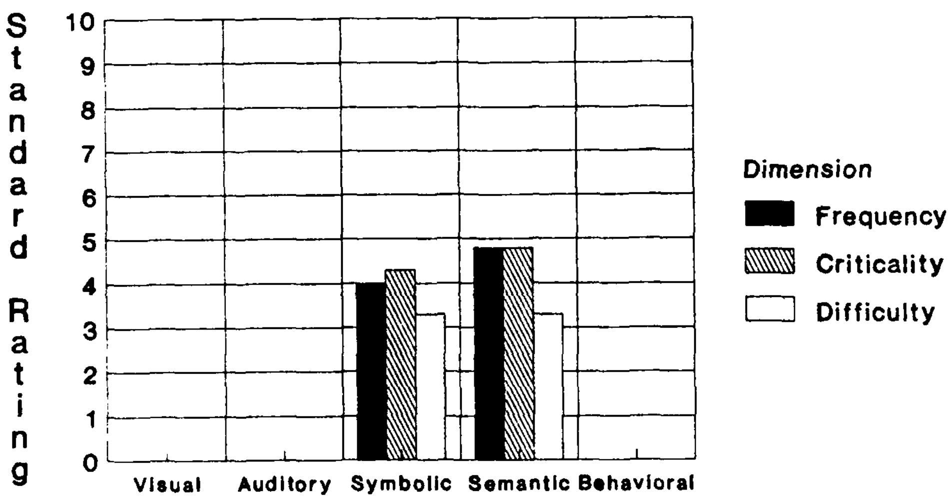
DSAT Level 1 - Memory Operator for Debugging Domain



Domain Contents

11 Content-Products Identified

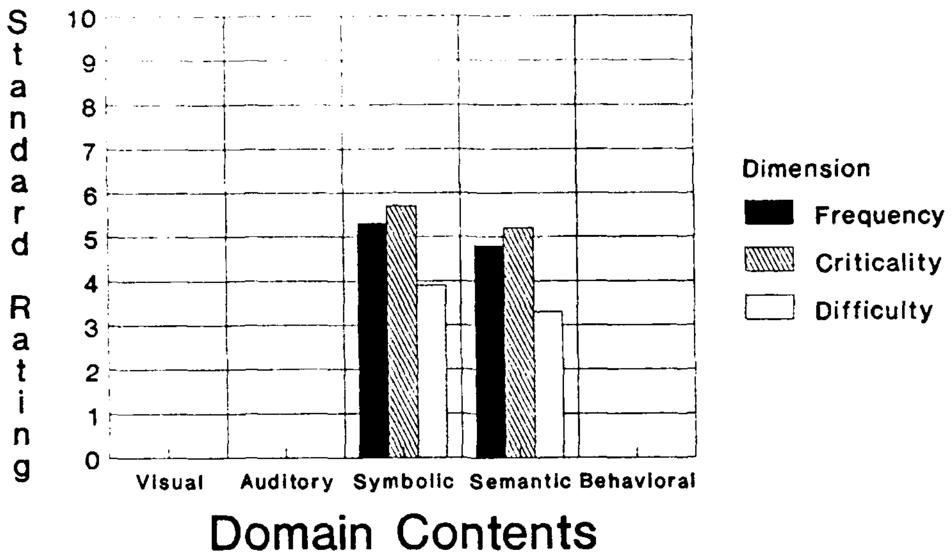
DSAT Level 1 - Divergent Production for Debugging Domain



Domain Contents

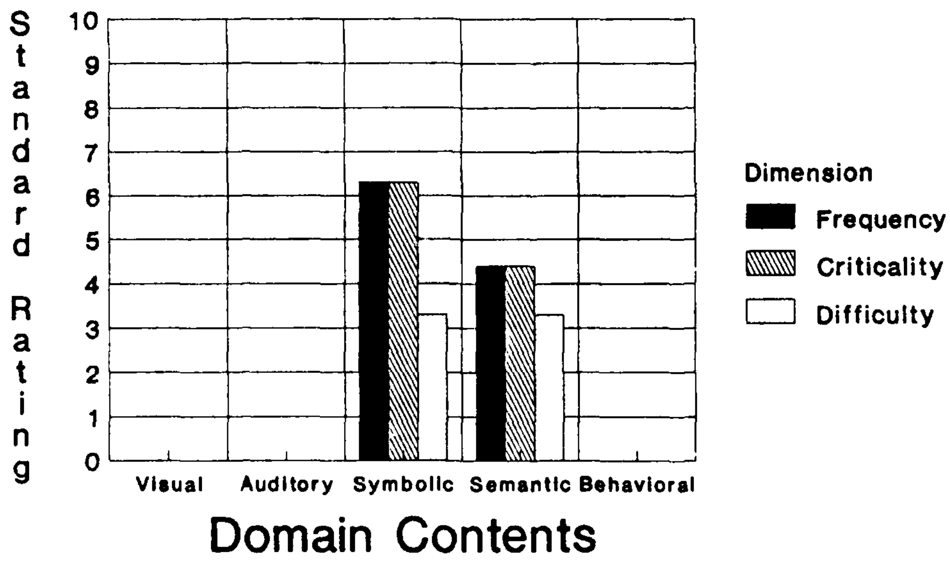
11 Content-Products Identified

DSAT Level 1 - Convergent Production for Debugging Domain



11 Content-Products Identified

DSAT Level 1 - Evaluation Operator for Debugging Domain



11 Content-Products Identified

APPENDIX C. RESEARCH PROPOSAL DOMAIN DSAT DATA

APPENDIX C1

RESEARCH PROPOSAL SUBMISSION DOMAIN DSAT DATA

LEVEL ZERO DATA SUMMARY

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	10	10	3.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	10	0.0	0.0	0.0
B I CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C S RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	3.3	0.0	0.0	0.0
D U SYST	0.0	0.0	0.0	6.0	2.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	2.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	3.3	4.0	4.0	6.7
OPER AVG	6.0	7.0	3.3	6.0	2.0	6.7	0.0	0.0	0.0	2.7	2.7	5.4	4.0	4.0	6.7
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	4.0	8.0	10	4.0	4.0	10	0.0	0.0	0.0	4.0	4.0	10	4.0	4.0	3.3
OPER AVG	0.7	1.3	1.7	0.7	0.7	1.7	0.0	0.0	0.0	0.7	0.7	1.7	0.7	0.7	0.6
M S UNTS	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N Y CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O M RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	6.7
P B SYST	8.0	8.0	10	6.0	4.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q O TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R L IMPL	6.0	6.0	10	0.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	10	0.0	0.0	0.0
OPER AVG	6.7	6.7	7.8	6.0	4.0	6.7	0.0	0.0	0.0	4.0	8.0	10	4.0	4.0	6.7
S S UNTS	10	10	10	10	10	10	6.0	8.0	10	4.0	4.0	10	6.0	8.0	10
T E CLSS	6.0	8.0	10	10	10	10	4.0	8.0	10	2.0	4.0	6.7	6.0	8.0	10
U M RELS	6.0	10	10	10	10	10	8.0	10	10	6.0	10	10	6.0	10	10
V A SYST	6.0	10	10	6.0	10	10	10	10	10	6.0	8.0	10	2.0	4.0	10
W N TRNS	6.0	10	10	6.0	10	10	6.0	10	10	8.0	8.0	10	6.0	6.0	10
X T IMPL	4.0	10	10	8.0	10	10	8	10	10	4.0	6.0	10	6.0	8.0	10
OPER AVG	6.3	9.7	10	8.3	10	10	7.0	9.3	10	5.0	6.7	9.5	5.3	7.3	10
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LEVEL TWO DATA SUMMARY

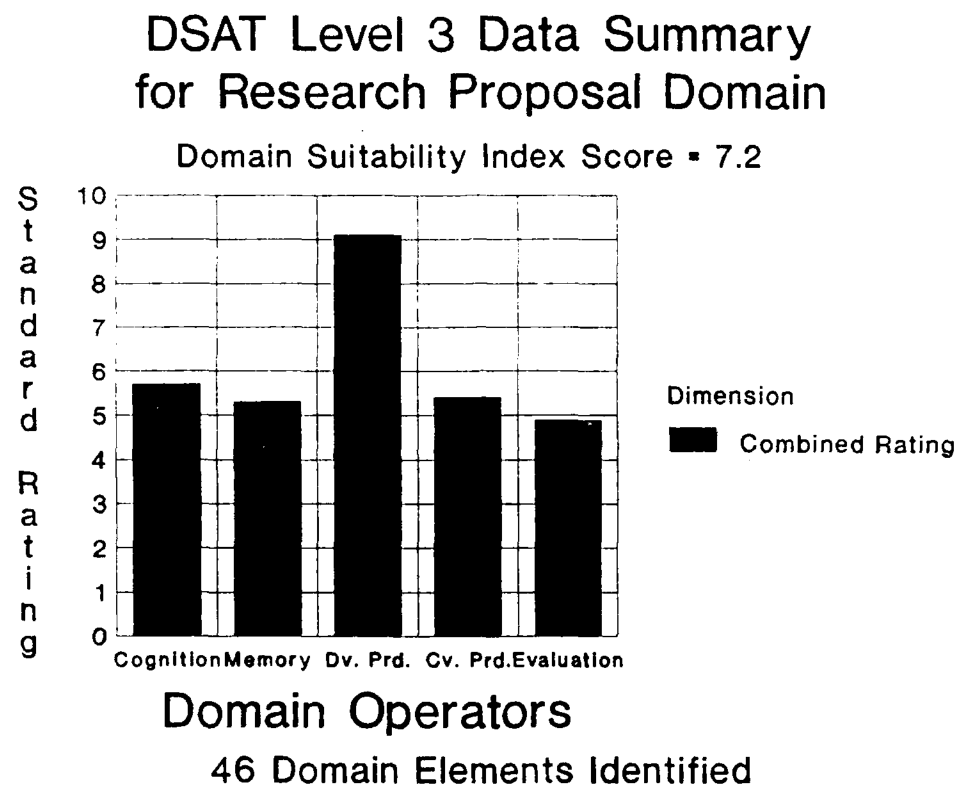
CONTENT	COGNITION F	COGNITION C	COGNITION D	MEMORY F	MEMORY C	MEMORY D	DIVT PRODN F	DIVT PRODN C	DIVT PRODN D	CONV PRODN F	CONV PRODN C	CONV PRODN D	EVALUATION F	EVALUATION C	EVALUATION D
VISUAL	6.0	7.0	3.3	6.0	2.0	6.7	0.0	0.0	0.0	2.7	2.7	5.4	4.0	4.0	6.7
AUDITORY	0.7	1.3	1.7	0.7	0.7	1.7	0.0	0.0	0.0	0.7	0.7	1.7	0.7	0.7	0.6
SYMBOLIC	6.7	6.7	7.8	6.0	4.0	6.7	0.0	0.0	0.0	4.0	8.0	10	4.0	4.0	6.7
SEMANTIC	6.3	9.7	10	8.3	10	10	7.0	9.3	10	5.0	6.7	9.5	5.3	7.3	10
BEHAVRL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	5.1	6.2	5.7	5.3	4.2	6.3	7.0	9.3	10	3.1	4.5	6.6	3.5	4.0	6.0

LEVEL THREE DATA SUMMARY

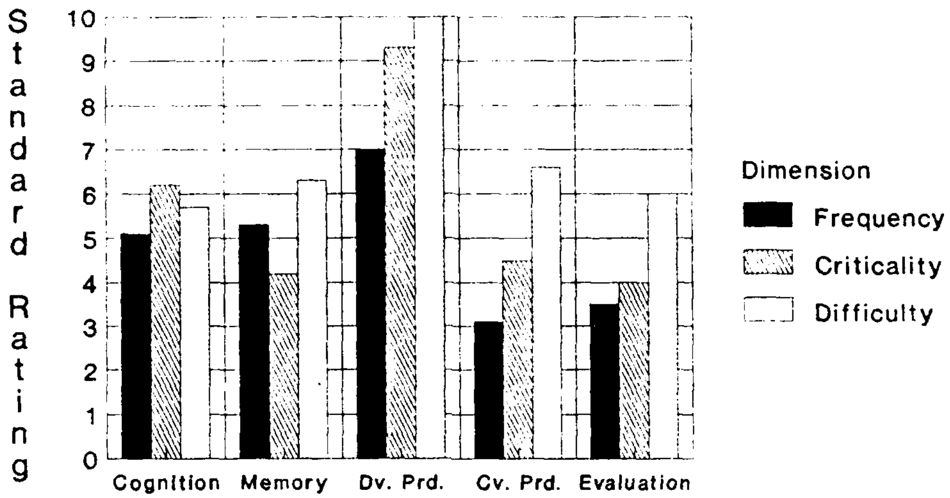
OPERATOR	F	C	D	N	FINAL RATING
COGNITION	5.1	6.2	5.7	12	5.7
MEMORY	5.3	4.2	6.3	9	5.3
DIVT. PROD.	7.0	9.3	10	6	9.1
CONV. PROD.	3.1	4.5	6.6	11	5.4
EVALUATION	3.5	4.0	6.0	9	4.9
DOMAIN AVERAGE	4.8	5.6	6.9	46	7.2

APPENDIX C2

RESEARCH PROPOSAL SUBMISSION DOMAIN DSAT LEVEL 1, 2, AND 3 GRAPHS



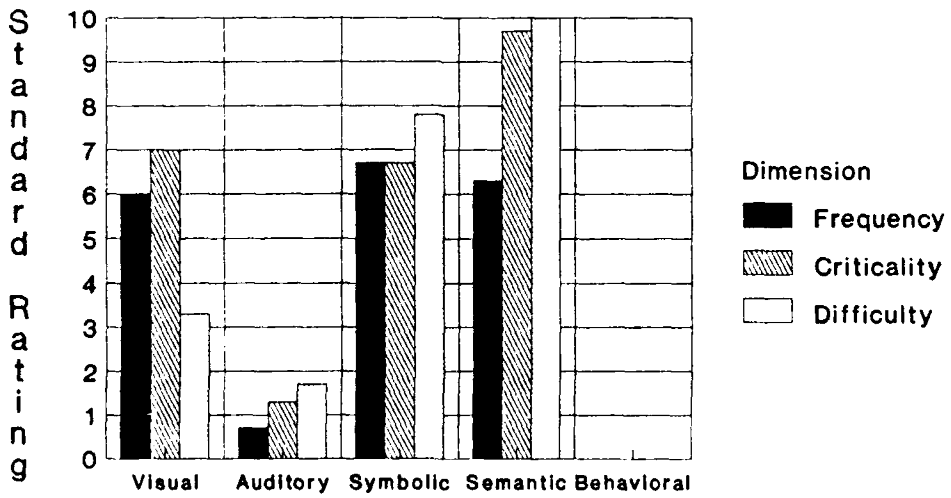
DSAT Level 2 Data Summary for Research Proposal Domain



Domain Operators

46 Domain Elements Identified

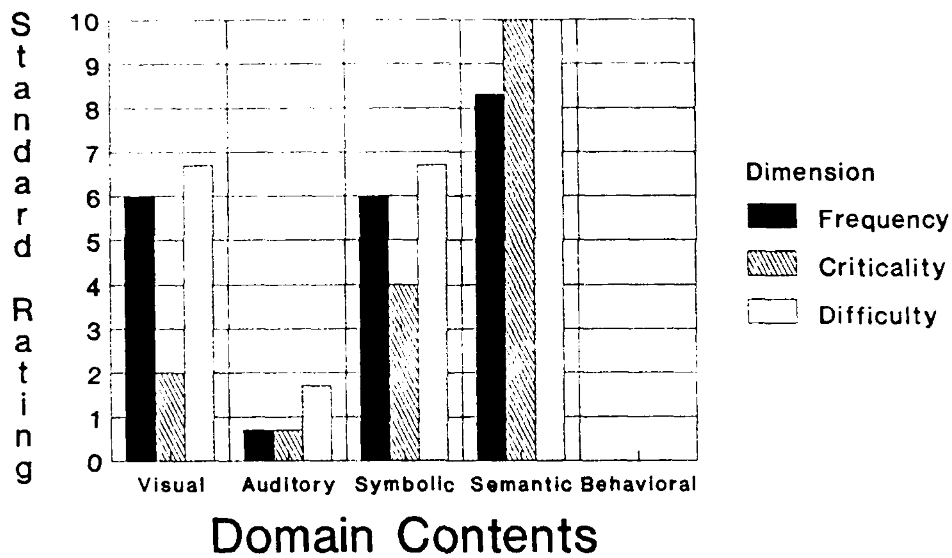
DSAT Level 1 - Cognition Operator for Research Proposal Domain



Domain Contents

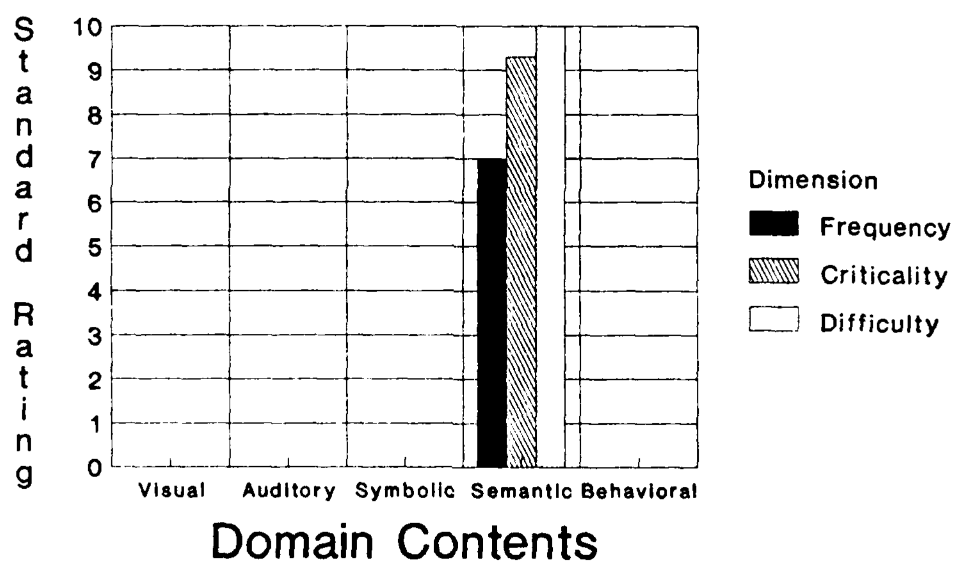
12 Content-Products Identified

DSAT Level 1 - Memory Operator for Research Proposal Domain



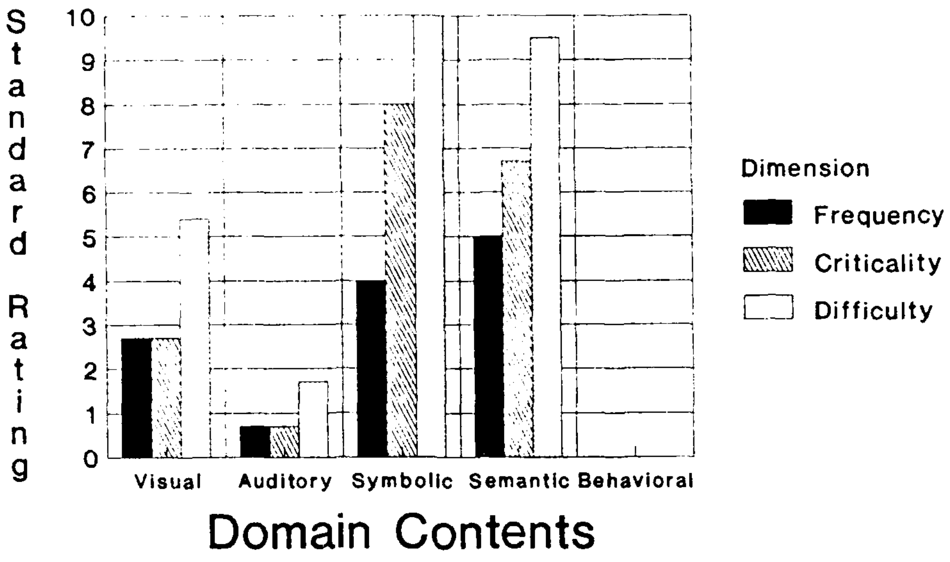
9 Content-Products Identified

DSAT Level 1 - Divergent Production for Research Proposal Domain



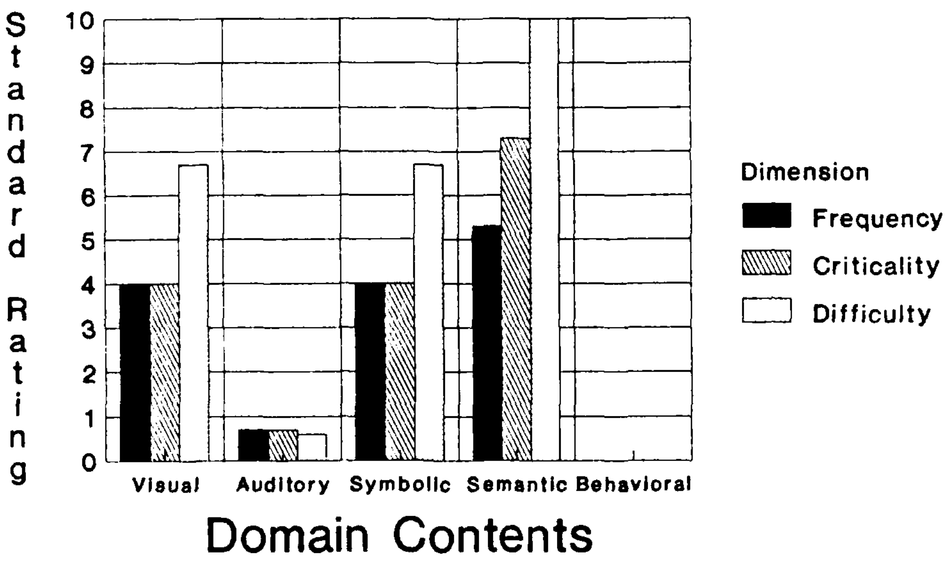
6 Content-Products Identified

DSAT Level 1 - Convergent Production for Research Proposal Domain



11 Content-Products Identified

DSAT Level 1 - Evaluation Operator for Research Proposal Domain



9 Content-Products Identified

APPENDIX D. GIFTED CHILD ASSESSMENT DOMAIN DSAT DATA

APPENDIX D1

GIFTED CHILD ASSESSMENT DOMAIN DSAT DATA

LEVEL ZERO DATA SUMMARY

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	6.0	8.0	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	10	10
B I CLSS	4.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	10	3.3
C S RELS	6.0	6.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	10	3.3
D U SYST	2.0	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	3.3
E A TRNS	2.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	4.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	3.3
OPER AVG	4.0	6.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	9.2	4.6
G A UNTS	8.0	8.0	6.7	0.0	0.0	0.0	2.0	6.0	3.3	2.0	4.0	3.3	8.0	8.0	6.7
H U CLSS	6.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0	3.3	2.0	4.0	3.3
I D RELS	6.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0	3.3
J I SYST	4.0	6.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0	3.3	0.0	0.0	0.0
K T TRNS	6.0	6.0	6.7	0.0	0.0	0.0	2.0	4.0	3.3	2.0	4.0	3.3	0.0	0.0	0.0
L Y IMPL	8.0	8.0	10	0.0	0.0	0.0	2.0	4.0	3.3	2.0	4.0	3.3	6.0	8.0	3.3
OPER AVG	6.3	7.3	7.3	0.0	0.0	0.0	2.0	4.7	3.3	2.0	4.0	3.3	4.5	6.0	4.2
M S UNTS	6.0	8.0	10	10	10	3.3	6.0	6.0	3.3	0.0	0.0	0.0	6.0	8.0	3.3
N Y CLSS	8.0	8.0	10	0.0	0.0	0.0	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
O M RELS	8.0	10	10	10	10	6.7	0.0	0.0	0.0	0.0	0.0	0.0	6.0	10	3.3
P B SYST	4.0	6.0	6.7	10	10	10	0.0	0.0	0.0	0.0	0.0	0.0	6.0	8.0	3.3
Q O TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	8.0	6.7
R L IMPL	6.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	6.4	8.0	8.7	10	10	6.7	5.0	5.0	3.3	0.0	0.0	0.0	6.0	8.5	4.2
S S UNTS	6.0	10	10	6.0	6.0	6.7	6.0	6.0	6.7	8.0	10	6.7	8.0	10	6.7
T E CLSS	4.0	8.0	10	6.0	6.0	6.7	0.0	0.0	0.0	8.0	10	6.7	8.0	10	6.7
U M RELS	2.0	8.0	10	10	8.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	6.0	6.0	3.3
V A SYST	2.0	6.0	6.7	8.0	8.0	3.3	0.0	0.0	0.0	8.0	10	6.7	4.0	4.0	3.3
W N TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	2.0	4.0	6.7	10	8.0	3.3	4.0	6.0	6.7	6.0	10	10	4.0	6.0	3.3
OPER AVG	3.2	7.2	8.7	8.0	7.2	4.7	5.0	6.0	6.7	7.5	10	7.5	6.0	7.2	4.7
Y B UNTS	8.0	8.0	6.7	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	6.7
Z E CLSS	8.0	8.0	6.7	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	8.0	8.0	6.7	2.0	2.0	3.3	2.0	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	8.0	8.0	6.7	3.3	3.3	3.3	2.0	2.0	3.3	0.0	0.0	0.0	4.0	8.0	6.7

LEVEL TWO DATA SUMMARY

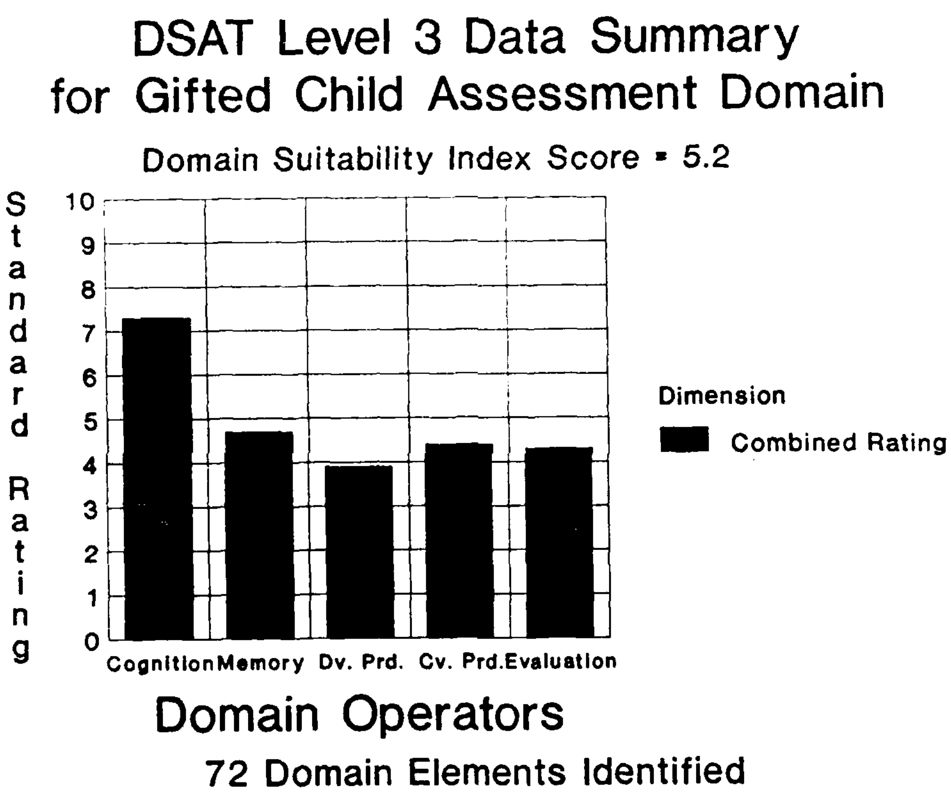
	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PRODUCT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
VISUAL	4.0	6.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	9.2	4.6
AUDITORY	6.3	7.3	7.3	0.0	0.0	0.0	2.0	4.7	3.3	2.0	4.0	3.3	4.5	6.0	4.2
SYMBOLIC	6.4	8.0	8.7	10	10	6.7	5.0	5.0	3.3	0.0	0.0	0.0	6.0	8.5	4.2
SEMANTIC	3.2	7.2	8.7	8.0	7.2	4.7	5.0	6.0	6.7	7.5	10	7.5	6.0	7.2	4.7
BEHAVRL	8.0	8.0	6.7	3.3	3.3	3.3	2.0	2.0	3.3	0.0	0.0	0.0	4.0	8.0	6.7
OPER AVG	5.6	7.3	7.5	7.1	6.8	4.9	3.5	4.4	4.2	2.4	3.5	2.7	5.1	7.8	4.9

LEVEL THREE DATA SUMMARY

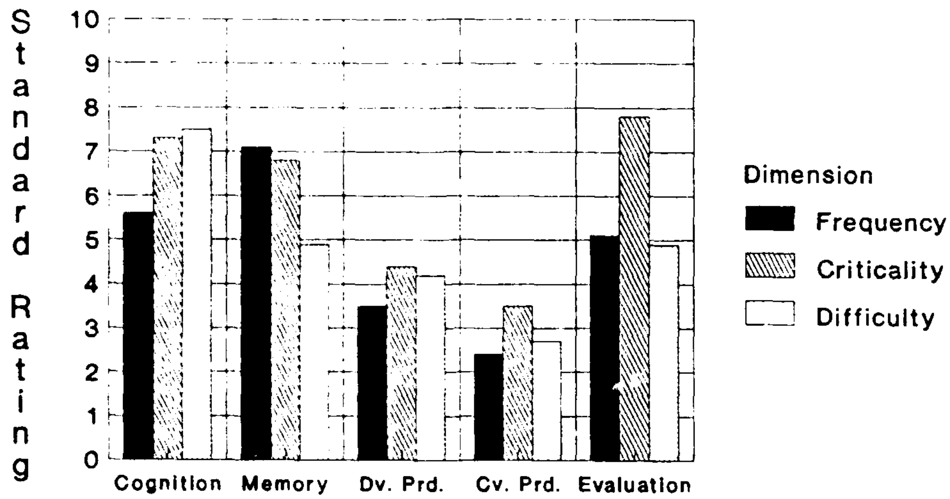
OPERATOR	F	C	D	N	FINAL RATING
COGNITION	5.6	7.3	7.5	25	7.3
MEMORY	7.1	6.8	4.9	11	5.7
DIVT. PROD.	3.5	4.4	4.2	8	4.1
CONV. PROD.	2.4	3.5	2.7	9	3.0
EVALUATION	5.1	7.8	4.9	19	6.0
DOMAIN AVERAGE	4.7	6.0	4.8	72	5.2

APPENDIX D2

GIFTED CHILD ASSESSMENT DOMAIN DSAT LEVEL 1, 2, and 3 GRAPHS



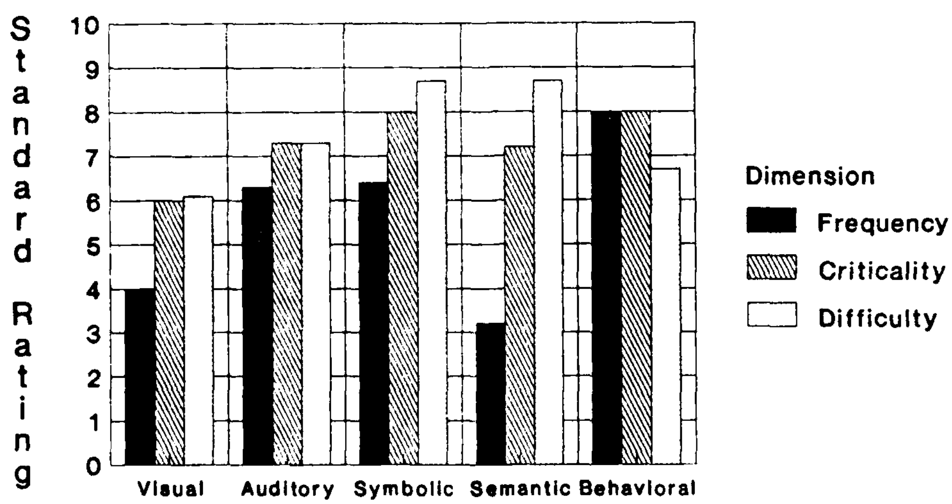
DSAT Level 2 Data Summary for Gifted Child Assessment Domain



Domain Operators

72 Domain Elements Identified

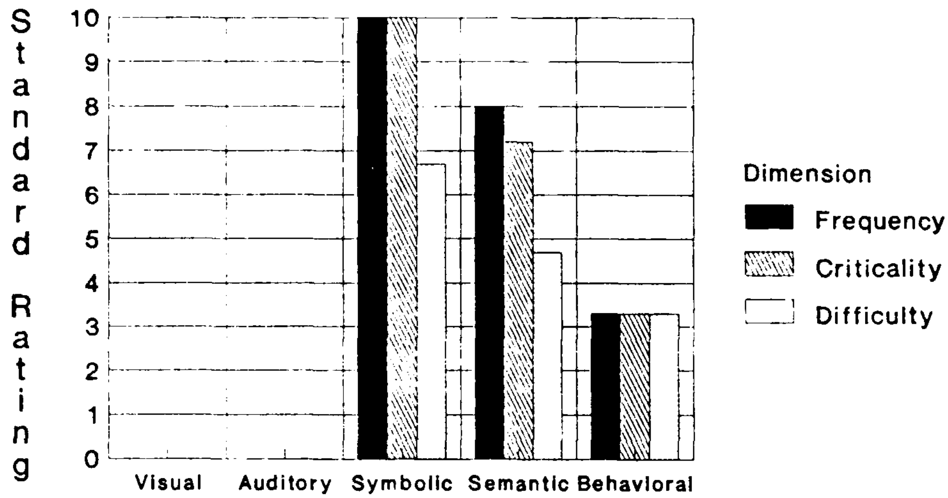
DSAT Level 1 - Cognition Operator for Gifted Child Assessment Domain



Domain Contents

25 Content-Products Identified

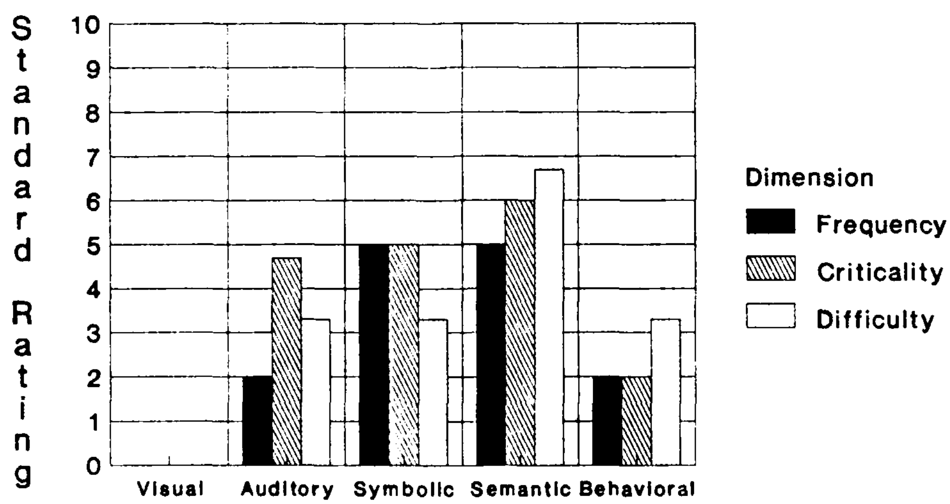
DSAT Level 1 - Memory Operator for Gifted Child Assessment Domain



Domain Contents

11 Content-Products Identified

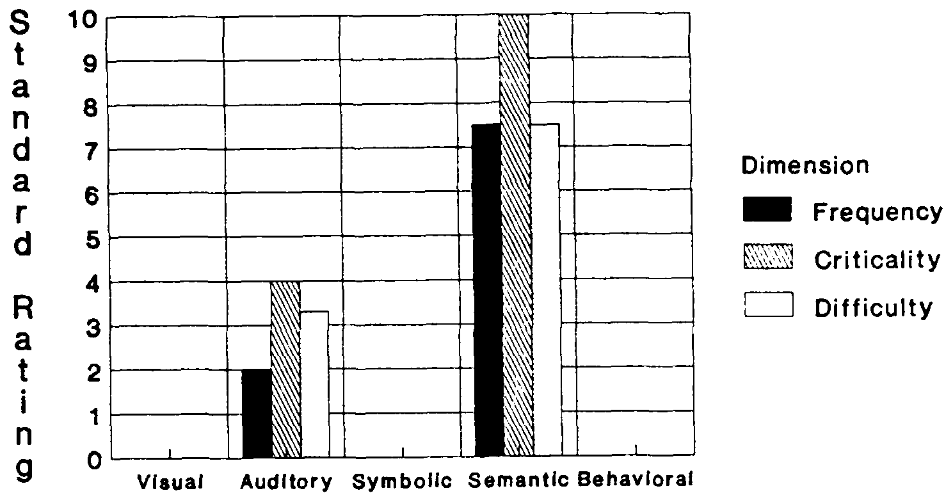
DSAT Level 1 - Divergent Production for Gifted Child Assessment Domain



Domain Contents

8 Content-Products Identified

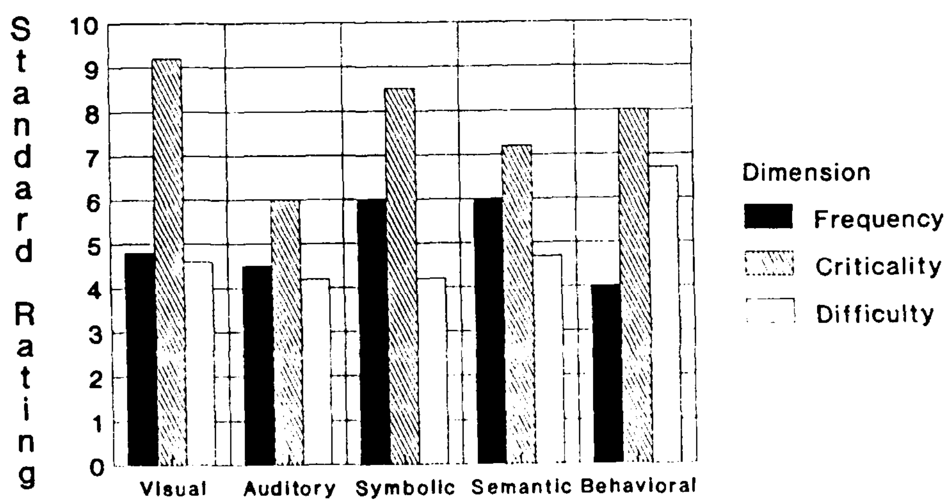
DSAT Level 1 - Convergent Production for Gifted Child Assessment Domain



Domain Contents

9 Content-Products Identified

DSAT Level 1 - Evaluation Operator for Gifted Child Assessment Domain



Domain Contents

19 Content-Products Identified

APPENDIX E. SUBJECT INFORMED CONSENT FORM

APPENDIX E

SUBJECT INFORMED CONSENT FORM

April 3, 1989

To Whom It May Concern:

The results of the research project you are participating in today will provide information to determine the reliability and aid in the refinement of a domain suitability analysis tool. During one experimental session of approximately one hour and forty-five minutes you will be asked to complete a questionnaire to determine and rate various aspects of information you use and the mental processes you use when performing the task of debugging a small (less than 200 lines of code) non-complex computer program with specific inputs and outputs. Potential risks associated with this experiment are similar to any rating task. You will be assigned a random identification number and this number will be used to identify your data; your name will not appear in any records of this experiment. If you have any questions, please feel to contact the experimenter, Jay Horn, at 233-0307 or Dr. Richard Koubek at 873-2701. At the conclusion of this research, a summary of group results will be avilable from the experimenter upon request.

I have read the above information and understand that participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled and I may discontinue participation at any time without penalty or loss of benefits to which I am otherwise entitled. I realize completion of the tasks implies my consent to participate.

____________________________ ____________________

Signature Date

APPENDIX F. SUBJECT LEVEL ZERO DATA SUMMARIES FOR DSAT RELIABILITY STUDY

APPENDIX F1

LEVEL ZERO DATA SUMMARY

SUBJECT 1 9 YEARS EXPERIENCE

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	10	10	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B I CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C S RELS	6.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D U SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	8.0	8.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	10	3.3	6.0	8.0	3.3	6.0	6.0	3.3	8.0	8.0	3.3	8.0	8.0	3.3
N Y CLSS	8.0	8.0	6.7	4.0	4.0	3.3	2.0	2.0	3.3	8.0	8.0	3.3	6.0	6.0	3.3
O M RELS	6.0	8.0	6.7	8.0	8.0	3.3	6.0	6.0	3.3	6.0	8.0	6.7	10	10	3.3
P B SYST	8.0	6.0	10	6.0	6.0	3.3	6.0	6.0	3.3	4.0	4.0	3.3	4.0	4.0	3.3
Q O TRNS	4.0	6.0	3.3	6.0	6.0	3.3	2.0	2.0	3.3	4.0	4.0	3.3	6.0	6.0	3.3
R L IMPL	6.0	6.0	3.3	6.0	8.0	3.3	2.0	4.0	3.3	2.0	2.0	3.3	4.0	4.0	3.3
OPER AVG	7.0	7.3	5.6	6.0	6.7	3.3	4.0	4.3	3.3	5.3	5.7	3.9	6.3	6.3	3.3
S S UNTS	6.0	6.0	3.3	4.0	6.0	3.3	2.0	4.0	3.3	6.0	6.0	3.3	4.0	6.0	3.3
T E CLSS	4.0	4.0	3.3	4.0	4.0	3.3	4.0	4.0	3.3	4.0	6.0	3.3	6.0	4.0	3.3
U M RELS	8.0	8.0	3.3	6.0	8.0	3.3	4.0	2.0	3.3	2.0	2.0	3.3	4.0	4.0	3.3
V A SYST	6.0	6.0	3.3	8.0	8.0	3.3	4.0	4.0	3.3	6.0	6.0	3.3	4.0	4.0	3.3
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	4.0	4.0	3.3	6.0	6.0	3.3	10	10	3.3	6.0	6.0	3.3	4.0	4.0	3.3
OPER AVG	5.6	5.6	3.3	5.6	6.4	3.3	4.8	4.8	3.3	4.8	5.2	3.3	4.4	4.4	3.3
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F2

LEVEL ZERO DATA SUMMARY

SUBJECT 2 8 YEARS EXPERIENCE

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	10	10	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B I CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C S RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D U SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	10	10	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	10	3.3	2.0	4.0	3.3	0.0	0.0	0.0	4.0	6.0	3.3	6.0	10	3.3
N Y CLSS	8.0	6.0	3.3	2.0	4.0	3.3	0.0	0.0	0.0	4.0	6.0	3.3	6.0	6.0	3.3
O M RELS	4.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	3.3	8.0	8.0	3.3
P B SYST	8.0	8.0	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	4.0	3.3
Q O TRNS	4.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	3.3	6.0	4.0	3.3
R L IMPL	6.0	8.0	3.3	6.0	6.0	3.3	2.0	4.0	3.3	4.0	4.0	3.3	6.0	6.0	3.3
OPER AVG	6.7	7.3	4.4	3.3	4.5	3.3	2.0	4.0	3.3	4.0	5.6	3.3	6.3	6.3	3.3
S S UNTS	2.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	3.3	4.0	4.0	3.3
T E CLSS	2.0	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0	3.3	2.0	2.0	3.3
U M RELS	2.0	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0	3.3	4.0	4.0	3.3
V A SYST	4.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	3.3	4.0	4.0	3.3
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	4.0	8.0	3.3	2.0	6.0	3.3	8.0	10	3.3	4.0	6.0	3.3	6.0	8.0	3.3
OPER AVG	5.6	5.6	3.3	2.0	6.0	3.3	8.0	10	3.3	2.5	3.6	3.3	4.0	4.5	3.3
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F3

LEVEL ZERO DATA SUMMARY

SUBJECT 3 11 YEARS EXPERIENCE

QUESTION/ PROD-CONT	COGNITION F	COGNITION C	COGNITION D	MEMORY F	MEMORY C	MEMORY D	DIVT PRODN F	DIVT PRODN C	DIVT PRODN D	CONV PRODN F	CONV PRODN C	CONV PRODN D	EVALUATION F	EVALUATION C	EVALUATION D
A V UNTS	10	10	3.3	8.0	2.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0	3.3
B I CLSS	8.0	8.0	3.3	4.0	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0	3.3
C S RELS	4.0	6.0	6.7	6.0	6.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	6.7
D U SYST	8.0	8.0	3.3	8.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	6.7
E A TRNS	4.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0	6.7
F L IMPL	4.0	6.0	3.3	2.0	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	3.3
OPER AVG	6.3	7.7	4.4	5.6	3.6	4.7	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.0	5.0
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	10	6.7	8.0	8.0	6.7	0.0	0.0	0.0	10	10	3.3	10	10	3.3
N Y CLSS	8.0	6.0	3.3	8.0	8.0	3.3	0.0	0.0	0.0	8.0	8.0	3.3	8.0	8.0	3.3
O M RELS	4.0	8.0	10	6.0	6.0	3.3	0.0	0.0	0.0	8.0	8.0	6.7	8.0	10	6.7
P B SYST	4.0	8.0	10	8.0	6.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	8.0	8.0	3.3
Q O TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	4.0	3.3
R L IMPL	8.0	8.0	3.3	4.0	4.0	6.7	0.0	0.0	0.0	2.0	2.0	3.3	6.0	4.0	3.3
OPER AVG	6.8	8.0	6.7	6.8	6.4	5.3	0.0	0.0	0.0	7.0	7.0	4.2	7.7	7.3	3.9
S S UNTS	6.0	8.0	3.3	6.0	6.0	3.3	0.0	0.0	0.0	6.0	4.0	6.7	6.0	8.0	3.3
T E CLSS	2.0	4.0	3.3	6.0	4.0	3.3	0.0	0.0	0.0	4.0	4.0	3.3	4.0	4.0	3.3
U M RELS	4.0	4.0	6.7	8.0	6.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	6.0	6.0	3.3
V A SYST	4.0	6.0	3.3	8.0	6.0	3.3	0.0	0.0	0.0	2.0	2.0	6.7	4.0	4.0	3.3
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	4.0	6.0	6.7	4.0	6.0	6.7	10	10	6.7	4.0	4.0	3.3	6.0	2.0	6.7
OPER AVG	4.0	5.6	4.7	6.4	5.6	4.7	10	10	6.7	4.0	3.5	5.0	5.2	4.8	4.0
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F4

LEVEL ZERO DATA SUMMARY

SUBJECT 4 12 YEARS EXPERIENCE

QUESTION/ PROD-CONT	COGNITION F	COGNITION C	COGNITION D	MEMORY F	MEMORY C	MEMORY D	DIVT PRODN F	DIVT PRODN C	DIVT PRODN D	CONV PRODN F	CONV PRODN C	CONV PRODN D	EVALUATION F	EVALUATION C	EVALUATION D
A V UNTS	10	10	6.7	10	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	6.0	8.0	3.3
B I CLSS	8.0	8.0	6.7	10	8.0	6.7	6.0	10	6.7	0.0	0.0	0.0	6.0	6.0	6.7
C S RELS	8.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D U SYST	0.0	0.0	0.0	6.0	8.0	6.7	6.0	6.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	10	8.0	3.3	10	10	3.3	10	10	6.7	6.0	8.0	3.3	0.0	0.0	0.0
OPER AVG	9.0	8.5	5.9	9.0	8.5	5.9	7.3	8.7	6.7	6.0	8.0	3.3	2.0	2.3	1.7
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	10	3.3	10	10	6.7	6.0	8.0	3.3	10	10	3.3	10	8.0	6.7
N Y CLSS	10	10	3.3	8.0	8.0	3.3	0.0	0.0	0.0	8.0	6.0	10	8.0	8.0	6.7
O M RELS	6.0	6.0	6.7	8.0	8.0	3.3	4.0	6.0	3.3	6.0	8.0	6.7	8.0	8.0	6.7
P B SYST	10	10	6.7	8.0	8.0	6.7	6.0	8.0	3.3	8.0	6.0	6.7	8.0	10	3.3
Q O TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R L IMPL	10	10	10	8.0	10	6.7	6.0	6.0	6.7	10	10	6.7	8.0	8.0	6.7
OPER AVG	9.2	9.2	6.0	8.4	8.8	5.3	5.5	7.0	4.2	8.4	8.0	6.7	8.4	8.4	6.0
S S UNTS	10	8.0	6.7	6.0	6.0	6.7	0.0	0.0	0.0	6.0	6.0	6.7	6.0	6.0	3.3
T E CLSS	6.0	6.0	6.7	8.0	6.0	3.3	4.0	6.0	6.7	8.0	6.0	3.3	6.0	8.0	6.7
U M RELS	0.0	0.0	0.0	6.0	8.0	6.7	4.0	6.0	6.7	8.0	10	6.7	6.0	6.0	6.7
V A SYST	6.0	8.0	6.7	6.0	6.0	3.3	6.0	8.0	3.3	6.0	8.0	3.3	6.0	8.0	6.7
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	6.0	8.0	6.7	8.0	10	6.7	8.0	10	6.7	10	10	6.7	6.0	6.0	3.3
OPER AVG	7.0	7.5	6.7	6.8	7.2	5.3	5.5	7.5	5.9	7.6	8.0	5.3	6.0	6.8	5.3
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F5

LEVEL ZERO DATA SUMMARY

SUBJECT 5 5 YEARS EXPERIENCE

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	10	10	6.7	2.0	4.0	10	0.0	0.0	0.0	6.0	8.0	6.7	4.0	2.0	6.7
B I CLSS	6.0	4.0	6.7	6.0	8.0	6.7	2.0	8.0	3.3	0.0	0.0	0.0	2.0	2.0	3.3
C S RELS	0.0	0.0	0.0	6.0	4.0	6.7	0.0	0.0	0.0	2.0	2.0	3.3	4.0	6.0	6.7
D U SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	8.0	10	10	2.0	4.0	10	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.0	3.3
F L IMPL	4.0	4.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	10
OPER AVG	7.0	7.0	7.5	4.0	5.0	8.4	2.0	8.0	3.3	4.0	5.0	5.0	3.2	4.8	6.0
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	8.0	3.3	10	10	3.3	4.0	8.0	6.7	6.0	8.0	6.7	4.0	8.0	10
N Y CLSS	6.0	4.0	6.7	4.0	6.0	6.7	6.0	6.0	6.7	2.0	6.0	6.7	6.0	10	3.3
O M RELS	6.0	10	10	2.0	6.0	10	2.0	6.0	10	6.0	10	10	8.0	10	10
P B SYST	2.0	4.0	6.7	8.0	8.0	6.7	0.0	0.0	0.0	4.0	6.0	10	8.0	6.0	3.3
Q O TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R L IMPL	6.0	8.0	6.7	10	8.0	3.3	4.0	2.0	6.7	2.0	6.0	10	4.0	4.0	3.3
OPER AVG	6.0	6.8	6.7	6.8	7.6	6.0	4.0	5.5	7.5	4.0	7.2	8.7	6.0	7.6	6.0
S S UNTS	4.0	6.0	6.7	2.0	2.0	6.7	4.0	6.0	10	2.0	4.0	3.3	4.0	4.0	6.7
T E CLSS	8.0	8.0	3.3	4.0	6.0	3.3	4.0	2.0	3.3	4.0	4.0	6.7	4.0	6.0	3.3
U M RELS	2.0	2.0	6.7	6.0	4.0	3.3	6.0	2.0	3.3	4.0	6.0	3.3	6.0	6.0	6.7
V A SYST	8.0	10	6.7	8.0	10	3.3	4.0	6.0	6.7	8.0	10	3.3	0.0	0.0	0.0
W N TRAN	0.0	0.0	0.0	4.0	6.0	6.7	4.0	8.0	6.7	4.0	4.0	3.3	2.0	4.0	3.3
X T IMPL	6.0	6.0	3.3	2.0	8.0	3.3	6.0	10	6.7	4.0	6.0	6.7	6.0	8.0	3.3
OPER AVG	5.6	6.4	5.3	4.3	6.0	4.4	4.7	5.7	6.1	4.3	5.7	4.4	4.4	5.6	4.7
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F6

LEVEL ZERO DATA SUMMARY

SUBJECT 6 5 YEARS EXPERIENCE

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	6.0	8.0	6.7	4.0	6.0	6.7	0.0	0.0	0.0	4.0	6.0	6.7	6.0	6.0	6.7
B I CLSS	10	10	3.3	8.0	6.0	3.3	0.0	0.0	0.0	4.0	6.0	6.7	6.0	6.0	3.3
C S RELS	6.0	6.0	3.3	4.0	6.0	6.7	0.0	0.0	0.0	4.0	4.0	3.3	4.0	6.0	3.3
D U SYST	10	10	3.3	10	6.0	3.3	0.0	0.0	0.0	6.0	8.0	3.3	6.0	6.0	3.3
E A TRNS	4.0	10	6.7	6.0	6.0	3.3	0.0	0.0	0.0	6.0	8.0	6.7	8.0	8.0	3.3
F L IMPL	6.0	10	6.7	4.0	6.0	6.7	0.0	0.0	0.0	4.0	8.0	6.7	6.0	6.0	3.3
OPER AVG	7.0	9.0	5.0	6.0	6.0	5.0	0.0	0.0	0.0	4.7	6.7	5.6	6.0	6.3	3.9
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	8.0	8.0	6.7	10	10	6.7	0.0	0.0	0.0	8.0	10	3.3	4.0	6.0	3.3
N Y CLSS	6.0	8.0	6.7	2.0	4.0	3.3	0.0	0.0	0.0	4.0	8.0	6.7	6.0	10	3.3
O M RELS	8.0	10	10	6.0	10	6.7	0.0	0.0	0.0	2.0	2.0	3.3	8.0	10	3.3
P B SYST	4.0	8.0	6.7	6.0	6.0	6.7	0.0	0.0	0.0	2.0	2.0	3.3	2.0	6.0	3.3
Q O TRNS	6.0	10	6.7	6.0	8.0	6.7	0.0	0.0	0.0	2.0	2.0	3.3	6.0	8.0	6.7
R L IMPL	4.0	8.0	10	6.0	8.0	6.7	0.0	0.0	0.0	6.0	6.0	3.3	4.0	6.0	3.3
OPER AVG	6.0	8.7	7.8	6.0	7.7	6.1	0.0	0.0	0.0	4.0	5.0	3.9	5.0	7.7	3.9
S S UNTS	4.0	6.0	6.7	8.0	10	6.7	0.0	0.0	0.0	4.0	6.0	3.3	4.0	8.0	6.7
T E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U M RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V A SYST	4.0	8.0	6.7	10	10	3.3	0.0	0.0	0.0	2.0	4.0	3.3	2.0	2.0	3.3
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	6.0	8.0	3.3	6.0	8.0	6.7	0.0	0.0	0.0	6.0	8.0	3.3	8.0	10	3.3
OPER AVG	4.7	7.3	5.6	8.0	9.3	5.6	0.0	0.0	0.0	4.0	6.0	3.3	4.7	6.7	4.4
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F7

LEVEL ZERO DATA SUMMARY

SUBJECT 7 — 10 YEARS EXPERIENCE

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QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	10	10	6.7	4.0	6.0	10	4.0	4.0	3.3	6.0	8.0	10	10	8.0	10
B I CLSS	10	10	10	4.0	4.0	10	2.0	4.0	6.7	4.0	6.0	10	4.0	6.0	10
C S RELS	4.0	8.0	6.7	4.0	6.0	6.7	6.0	8.0	10	8.0	10	10	6.0	6.0	10
D U SYST	6.0	10	10	6.0	8.0	10	8.0	10	10	6.0	8.0	10	6.0	6.0	10
E A TRNS	6.0	8.0	10	8.0	10	10	2.0	2.0	10	6.0	8.0	10	6.0	10	10
F L IMPL	4.0	6.0	10	6.0	6.0	10	6.0	6.0	6.7	8.0	6.0	10	4.0	6.0	10
OPER AVG	6.7	8.7	8.9	5.3	6.7	9.5	4.7	5.7	7.8	6.3	7.7	10	6.0	7.0	10
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	4.0	10	3.3	8.0	10	6.7	4.0	6.0	6.7	4.0	6.0	10	8.0	4.0	10
N Y CLSS	6.0	6.0	6.7	6.0	10	3.3	4.0	4.0	3.3	4.0	4.0	10	4.0	4.0	10
O M RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P B SYST	10	10	10	4.0	6.0	6.7	2.0	4.0	6.7	4.0	4.0	6.7	4.0	6.0	10
Q O TRNS	2.0	4.0	10	6.0	6.0	6.7	6.0	8.0	3.3	6.0	6.0	10	6.0	6.0	10
R L IMPL	6.0	4.0	6.7	4.0	6.0	6.7	2.0	4.0	3.3	6.0	6.0	3.3	2.0	4.0	3.3
OPER AVG	5.6	6.8	7.3	5.6	7.6	6.0	3.6	5.2	4.7	4.8	5.2	8.0	4.8	4.8	8.7
S S UNTS	4.0	8.0	10	6.0	4.0	6.7	4.0	6.0	10	6.0	8.0	6.7	4.0	6.0	10
T E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U M RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V A SYST	2.0	10	10	6.0	8.0	6.7	4.0	6.0	3.3	8.0	10	10	6.0	6.0	10
W N TRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X T IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	3.0	9.0	10	6.0	6.0	6.7	4.0	6.0	6.7	7.0	9.0	8.4	5.0	6.0	10
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F8

LEVEL ZERO DATA SUMMARY

SUBJECT 8 10 YEARS EXPERIENCE

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	6.0	10	3.3	6.0	6.0	3.3	8.0	8.0	6.7	6.0	10	6.7	6.0	10	6.7
B I CLSS	6.0	6.0	3.3	0.0	0.0	0.0	10	10	3.3	6.0	6.0	3.3	10	10	6.7
C S RELS	4.0	8.0	6.7	6.0	6.0	6.7	10	10	3.3	4.0	8.0	3.3	10	10	3.3
D U SYST	10	10	3.3	4.0	10	6.7	6.0	6.0	6.7	2.0	6.0	3.3	4.0	4.0	3.3
E A TRNS	6.0	6	3	4.0	4.0	3.3	4.0	10	3.3	6.0	10	3.3	4.0	10	6.7
F L IMPL	4.0	10	6.7	4.0	4.0	6.7	6.0	10	3.3	4.0	10	6.7	2.0	6.0	6.7
OPER AVG	6.0	8.3	4.4	5.8	6.0	5.3	7.3	9.0	4.4	4.7	8.3	4.4	6.0	8.3	5.6
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	4.0	8.0	6.7	4.0	4.0	6.7	4.0	8.0	6.7	4.0	10	6.7	4.0	6.0	6.7
N Y CLSS	4.0	8.0	6.7	10	10	3.3	4.0	10	6.7	0.0	0.0	0.0	10	10	3.3
O M RELS	8.0	10	6.7	10	10	3.3	6.0	6.0	6.7	10	10	6.7	10	10	6.7
P B SYST	8.0	8.0	3.3	6.0	6.0	3.3	6.0	6.0	6.7	10	10	6.7	10	10	3.3
Q O TRNS	6.0	6.0	6.7	4.0	4.0	6.7	4.0	8.0	10	6.0	6.0	3.3	6.0	6.0	3.3
R L IMPL	4.0	4.0	6.7	6.0	6.0	6.7	4.0	8.0	6.7	4.0	4.0	3.3	4.0	4.0	3.3
OPER AVG	5.7	7.3	6.1	6.7	6.7	5.0	4.7	7.7	7.3	6.8	8.0	5.3	7.3	7.7	4.4
S S UNTS	6.0	6.0	3.3	2.0	8.0	3.3	10	10	3	2.0	2.0	3.3	6.0	6.0	3.3
T E CLSS	8.0	8.0	3.3	2.0	8.0	6.7	4.0	8.0	6.7	2.0	2.0	3.3	4.0	4.0	3.3
U M RELS	10	10	3.3	2.0	10	3.3	4.0	4.0	6.7	6.0	6.0	3.3	6.0	6.0	3.3
V A SYST	4.0	10	6.7	4.0	8.0	6.7	4.0	10	6.7	10	10	6.7	4.0	4.0	6.7
W N TRAN	6.0	6.0	3.3	2.0	10	3.3	10	10	3.3	10	10	3.3	10	10	3.3
X T IMPL	10	10	6.7	4.0	10	6.7	6.0	10	6.7	4.0	4.0	3.3	4.0	8.0	6.7
OPER AVG	7.3	8.3	4.4	2.7	9.0	5.0	6.3	8.7	5.6	5.7	5.7	3.9	5.7	6.3	4.4
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F9

LEVEL ZERO DATA SUMMARY

SUBJECT 9 9 YEARS EXPERIENCE

QUESTION/		COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT		F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A	V UNTS	4.0	4.0	3.3	4.0	4.0	3.3	6.0	6.0	3.3	0.0	0.0	0.0	6.0	6.0	6.7
B	I CLSS	2.0	2.0	3.3	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C	S RELS	0.0	0.0	0.0	0.0	0.0	0.0	4.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
D	U SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	A TRNS	0.0	0.0	0.0	6.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	L IMPL	0.0	0.0	0.0	6.0	6.0	6.7	4.0	2.0	3.3	4.0	4.0	3.3	0.0	0.0	0.0
OPER AVG		3.0	3.0	3.3	5.0	5.0	4.2	4.7	4.7	3.3	4.0	4.0	3.3	6.0	6.0	6.7
G	A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H	U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I	D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J	I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K	T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L	Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M	S UNTS	10	10	6.7	10	10	6.7	8.0	8.0	3.3	2.0	2.0	3.3	10	10	3.3
N	Y CLSS	10	6.0	3.3	8.0	10	6.7	6.0	8.0	6.7	2.0	2.0	3.3	8.0	6.0	3.3
O	M RELS	10	10	6.7	6.0	6.0	6.7	4.0	4.0	3.3	6.0	8.0	6.7	10	10	3.3
P	B SYST	10	10	6.7	4.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q	O TRNS	6.0	8.0	10	8.0	8.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	6.0	4.0	3.3
R	L IMPL	10	10	10	10	8.0	6.7	0.0	0.0	0.0	4.0	4.0	3.3	10	10	3.3
OPER AVG		9.3	9.0	7.2	7.7	8.3	6.7	6.0	6.7	4.4	3.5	4.0	4.2	8.8	8.0	3.3
S	S UNTS	6.0	6.0	6.7	4.0	6.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	3.3
T	E CLSS	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U	M RELS	6.0	6.0	6.7	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	A SYST	8.0	8.0	6.7	2.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W	N TRAN	4.0	4.0	10	4.0	4.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X	T IMPL	10	10	6.7	2.0	4.0	3.3	0.0	0.0	0.0	6.0	6.0	3.3	0.0	0.0	0.0
OPER AVG		6.3	6.3	6.7	3.2	4.4	3.3	0.0	0.0	0.0	6.0	6.0	3.3	4.0	4.0	3.3
Y	B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z	E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA	H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB	A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC	V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD	L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F10

LEVEL ZERO DATA SUMMARY

SUBJECT 10 19 YEARS EXPERIENCE

QUESTION/	COGNITION			MEMORY			DIVT PRODN			CONV PRODN			EVALUATION		
PROD-CONT	F	C	D	F	C	D	F	C	D	F	C	D	F	C	D
A V UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B I CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C S RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D U SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E A TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G A UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H U CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I D RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J I SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K T TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L Y IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M S UNTS	10	10	6.7	6.0	6.0	10	2.0	4.0	10	6.0	6.0	10	6.0	6.0	10
N Y CLSS	10	10	6.7	8.0	6.0	10	4.0	6.0	10	6.0	6.0	10	4.0	6.0	10
O M RELS	6.0	6.0	10	6.0	6.0	10	2.0	2.0	10	6.0	6.0	10	8.0	6.0	10
P B SYST	10	10	10	4.0	4.0	10	10	10	6.7	2.0	4.0	10	4.0	2.0	6.7
Q O TRNS	6.0	8.0	10	4.0	4.0	10	8.0	8.0	10	6.0	6.0	10	10	10	10
R L IMPL	6.0	6.0	10	6.0	6.0	10	6.0	8.0	6.7	4.0	6.0	10	4.0	6.0	10
OPER AVG	8.0	8.3	8.9	5.7	5.3	10	5.3	6.3	8.9	5.0	5.7	10	6.0	6.0	9.5
S S UNTS	4.0	6.0	10	4.0	4.0	10	2.0	4.0	6.7	2.0	4.0	6.7	4.0	2.0	6.7
T E CLSS	4.0	4.0	10	2.0	4.0	10	4.0	4.0	3.3	2.0	2.0	3.3	4.0	4.0	6.7
U M RELS	2.0	4.0	10	2.0	2.0	10	2.0	6.0	10	6.0	6.0	6.7	4.0	4.0	6.7
V A SYST	6.0	6.0	10	4.0	2.0	10	6.0	4.0	3.3	6.0	6.0	10	6.0	4.0	6.7
W N TRAN	4.0	6.0	10	6.0	6.0	10	6.0	6.0	10	2.0	2.0	3.3	6.0	4.0	10
X T IMPL	2.0	2.0	10	8.0	6.0	10	10	10	10	6.0	8.0	10	4.0	4.0	10
OPER AVG	3.7	4.7	10	4.3	4.0	10	5.0	5.7	7.2	4.0	4.7	6.7	4.7	3.7	7.8
Y B UNTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Z E CLSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AA H RELS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BB A SYST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CC V TRNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DD L IMPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPER AVG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX G. SAS SOFTWARE DATA ANALYSIS PROGRAM

APPENDIX G

SAS SOFTWARE DATA ANALYSIS PROGRAM

```
DATA DSATREL;
  INPUT SUB EXP CF CC CD CN MF MC MD MN DF DC DD DN NF NC ND NN
  EF EC ED EN TN DSI @@;
     IF EXP => 10 THEN GROUP = 1;
     ELSE GROUP = 2;
  LIST;
  CARDS;
PROC PRINT;
  TITLE1 'DSAT RELIABILITY STUDY';
  TITLE2 'RAW DATA FROM SCALED RESPONSES';
PROC UNIVARIATE NORMAL;
  TITLE2 'UNIVARIATE STATISTICS FOR INDIVIDUAL INFO ELEMENTS';
  OPTIONS LS=72;
PROC SORT;
  BY EXP;
PROC CORR;
  VAR EXP CD MD DF DC DD DN ND ED DSI;
  TITLE2 'CORRELATION DATA FOR DIFFICULTY DIMENSION AND';
  TITLE3 'DIVERGENT PRODUCTION OPERATOR';
PROC ANOVA;
  CLASS GROUP;
  MODEL DSI = GROUP;
  TITLE2 'F-TEST OF MEAN DSI SCORE BASED ON LEVEL OF EXPERTISE';
```